ENGINEERING ORGANIZATION AND METHODS

JAMES E. THOMSON

McGRAW-HILL
INDUSTRIAL ORGANIZATION AND MANAGEMENT SERIES
L. C. Morrow, *Consulting Editor*

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ENGINEERING ORGANIZATION AND METHODS

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ENGINEERING ORGANIZATION AND METHODS

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DEDICATED TO THE MEMORY

OF MY MOTHER

GENEVA MAY THOMPSON

WHO IS RESPONSIBLE FOR ANY

SUCCESS I MAY ACHIEVE

PREFACE

In these days of modern industrial production, scientific management has become necessary for the engineering department—both to facilitate production and to reduce engineering costs. Although every engineering executive and supervisor may appear to be confronted with different problems, these actually differ only in detail and not in nature. The fundamental principles of engineering organization and methods can be modified to meet existing conditions and applied to every case.

With this thought in mind, the author has endeavored to present these principles, as nearly in the order of their application as possible, so that the engineering executive or supervisor can develop such detailed methods as seem best suited to his particular problem. In some cases the problem is treated in general, with emphasis upon principles and objectives rather than upon detail operation. Choice of an actual procedure rests with the reader. In other cases a detailed method is given for the accomplishment of a particular function. The one presented is considered by the author to represent the best current usage, based upon study of methods used by many organizations and proved by successful application in both large and small engineering departments. Detailed methods are given for all factors considered requisite to the orderly preparation, processing, recording, and release of engineering information; supporting service functions are usually given only general treatment.

All forms required for detail methods are fully described with examples of the proper usage of each. Forms shown in connection with general discussions do not receive detailed treatment for these represent only the general nature of the "paper" required to implement a particular function. Discussions of complex functions are concluded with a brief summary that provides an over-all "picture" of the methods involved.

The author is indebted to the Booth Manufacturing Corporation, The Ryan Aeronautical Company, Interstate Aircraft and Engineering Corporation, North American Aviation, Inc., and Consolidated-Vultee Aircraft Corporation for many of the specimen forms appearing in this book, and to the editor of *Product Engineering* for permission to use material from articles that have appeared in the pages of that magazine. Many individuals have contributed helpful suggestions during the prep-

aration of this book, and the author is indeed grateful for their kind assistance. He is particularly indebted to the stenographer who prepared the final manuscript, Mrs. Laura E. Weiler, for her patience and perseverance.

JAMES E. THOMPSON

SAN DIEGO, CALIF.
April, 1947

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ENGINEERING ORGANIZATION AND METHODS

CHAPTER 1
ORGANIZATION

Someone, somewhere, once stated that the organization and management of a business enterprise consisted of four progressive phases: analyzing, organizing, deputizing, and supervising. That statement not only is a masterpiece of brevity but is universally applicable to every organization problem—whether it is organization of an engineering department or a haberdashery. If it is conceded that analysis must precede organization, the first step in determining a logical engineering organization is establishing the proper functional pattern.

ESTABLISHING THE FUNCTIONAL PATTERN

To be sound, this functional pattern should be applicable to the engineering department of any manufacturing enterprise engaged in parts fabrication, regardless of the product under development. It is necessary to distinguish between firms engaged in parts fabrication and those occupied in materials processing, as their basic engineering functions are not the same. This can be demonstrated by comparing the engineering activities of a firm engaged in the manufacture of glass-fiber products with those of a producer of farm machinery. Both would need engineering departments, but the former would primarily require only product development and industrial engineering. The latter would require not only product development but also production engineering and a variety of technical and clerical services.

The engineering functional pattern is sufficiently different in each case to justify separate treatment, and this discussion will be devoted exclusively to organization and methods applicable to the engineering departments of concerns engaged in the fabrication and assembly of parts.

It is immaterial whether the parts involved comprise an airplane, a harvester, or a refrigerator. The basic functional pattern will be sub-

stantially the same; similar problems will be encountered; and the detail organization and methods required to solve these efficiently will be parallel in each case.

ENGINEERING DEPARTMENT FUNCTIONS

The obvious function of an engineering department is the production design of a given product or products. The execution of this function,

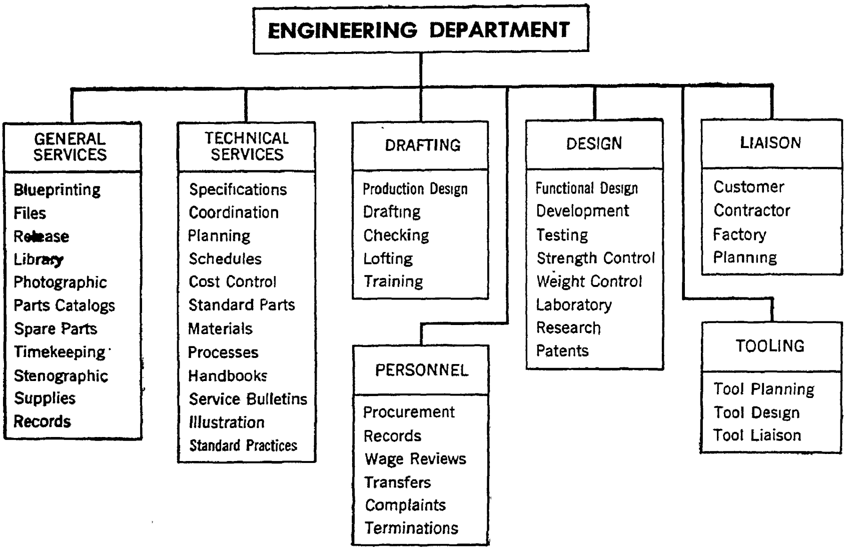


FIG. 1:1.—Engineering department functions.

however, requires a variety of supporting functions to develop the design, prepare necessary tooling, maintain liaison and coordination with other departments, provide nondrafting technical services, and maintain the necessary clerical functions and records.

Analysis of the operation of an engineering department readily reveals that its basic functions are (1) design, (2) drafting, (3) liaison, (4) technical services, (5) general services, and (6) personnel. All engineering activities can be grouped under these six headings, and the functional breakdown in Fig. 1:1 lists the work normally relating to each.

TOOL DESIGN

A seventh function of "tooling" is also shown in Fig. 1:1, but this is not considered as a prerequisite but rather as an optional activity. In

the case of an engineering department engaged in the design of small devices involving considerable machining, close coordination is needed between design and tooling. This can be done by establishing tool design as an engineering function, to be accomplished concurrently with product design.

Where the tooling program is extensive, as with automobile and aircraft designs, the tool-design department may be nearly as large as the engineering department. Good organization, then, demands that it be a separate department, responsible to the management and directed by a chief tool engineer. The coordination of tooling with design is accomplished by tool liaison engineers stationed in the engineering department. These liaison engineers cooperate with the design engineers to insure that the design is practicable to tool for production. All production drawings are approved by a tool liaison engineer prior to release for manufacture.

FUNCTIONAL DESIGN

The design section is concerned only with functional design, which establishes the basic arrangement of a product capable of the required performance and usually involves completion of a successful test model —sometimes the construction of actual pilot models in an experimental factory. The work shown under the design section of Fig. 1:1 relates solely to functional design and may be expanded or condensed to meet the design requirements of individual engineering departments engaged in particularized product development.

PRODUCTION DESIGN

The production-engineering phase begins immediately after the design is proved functionally correct. The production engineer translates the functional, experimental design into practical form. This process involves investigating the manufacturing economy of all detail parts, assemblies, and installations and the achievement of this economy without introducing changes that compromise the design's functional efficiency.

As the preparation of production drawings consumes the majority of man-hours spent upon production engineering, this function of the engineering department is grouped under the drafting phase, which includes checking all drawings, preparation of loft lines for articles involving developed surfaces, and training of personnel to accomplish the production engineering phase.

LIAISON ENGINEERING

The completion of the production design does not conclude the engineering department's task. Immediately upon release of drawings to the factory for manufacture there will begin the necessity for engineering liaison. Drawings will demand interpretation. The inevitable drawing errors will need "on-the-spot" correction to avoid halting manufacturing. Engineering authorization will be required to approve temporary drawing deviations in order to facilitate production and permit salvage of incorrectly manufactured parts.

Other phases of liaison may be required, including liaison between vendors and engineering in the case of subcontracts. Liaison with the production and tooling departments may be required properly to coordinate the production engineering with their needs and efforts.

ENGINEERING SERVICES

The engineering drawings, which convey the completed design to the manufacturing departments, are the most obvious display of the engineering department's work, but the designers and draftsmen alone cannot operate an engineering department. Their work must be supported and augmented by a variety of technical and general services.

The principal technical services required for the successful operation of an engineering department are planning, cost control, standards, methods, materials and processes, illustration, and technical data. Engineering planning is the most important of these, representing the means of orderly operation of the department. Planning is closely allied to scheduling, and the two combine to insure properly planned engineering work and completion within the time scheduled. Successful planning must be realistic; it must be in a position to inform management whether or not proposed design programs can be accomplished within the specified times. Management, on the other hand, must be willing to abide by the findings of Planning and not unwisely insist upon accomplishment of the impossible, to the ultimate discredit of the engineering department.

PLANNING AND SCHEDULING

Planning and scheduling are based upon the fundamental facts that certain maximum quantities of specialized man-hours are available within given calendar periods and that each job will require a portion of these hours. Therefore, it can be readily ascertained if new work can

be undertaken at any given time, and the completion date of each new job can be fairly accurately determined. Obviously, if the work in process at any given time will consume all available man-hours, it is impossible to assume additional work at that time—except by postponing the scheduled completion date of a portion of the current work. The only alternatives are holding the new work in abeyance until the man-hours required for current work drops below the maximum available or obtaining additional personnel.

COST CONTROL

Cost control is an absolute necessity for an organization that expects to operate on a competitive basis. It requires the establishment of an over-all budget for the engineering department, with individual budgets for each operating unit. Each unit must then operate within these budgets and be governed by the cost reports compiled by the cost engineering unit. These reports are obtained through a time-charge system, by which each hour spent by every engineering employee is allocated against the proper breakdown for each project or service.

Another phase of cost control involves close supervision of all designs to insure that each is engineered to the minimum manufacturing cost compatible with the required quality and performance. This can often be facilitated by the inauguration of a cost-improvement program within the engineering department, by which the individuals responsible for decreasing costs are rewarded.

STANDARD PARTS, DESIGNS AND METHODS

Standard parts and designs can greatly reduce the engineering expense by eliminating repeated detailing of small utility parts used generally throughout all designs. The creation of design standards for items such as fastener installations, electric wiring assemblies, conduit assemblies, and sheet metal cutouts eliminates constant repetition of extensive drawing notes and dimensioning.

Engineering methods must be developed and issued as standard-practice instructions to insure efficient, harmonious operation of the department. The basic methods for the successful operation and control of an engineering department involve (1) personnel organization and control, (2) drawing and report numbering, (3) drafting practices, (4) drawing release, (5) drawing and print control, (6) advance engineering information, (7) stop-work orders, (8) drawing-change requests, (9) drawing changes, and (10) liaison.

If a method is found to be wrong, it should be corrected immediately and revised instructions issued to all concerned. In no case should deviation from the established methods be permitted, even though correction of unorthodox work may temporarily delay the engineering program. The completion of the entire program will be accelerated by adhering, in all cases, to the established methods and insisting upon the immediate correction of work that fails to follow these.

The most dangerous condition that can develop in an engineering department is the "supercolossal rush" complex, where all semblance of order and accuracy are sacrificed in order to release drawings to the shop as soon as possible. The important act is releasing *accurate* information to the shop. Rushing unchecked, inaccurate, poorly designed work through the department and into the shop always defeats its own purpose. Eventually it delays completion of the finished article far longer than the time required to insure that every drawing is correct and released in the proper manner. Even worse, the release of "half-baked" information soon brings Engineering into ill repute and makes it impossible for that department to maintain its rightful position as the leader of the entire factory organization.

PERSONNEL CONTROL

The procurement and control of personnel has become an extremely complex matter in recent years, owing to wage and salary control, job classifications, labor-relations laws, and hiring restrictions. These circumstances justify the establishment of personnel control as a basic engineering function. In a small department these matters may be handled as a part-time function of one of the executives reporting to the chief engineer. As the department increases in size, it soon becomes necessary to establish personnel matters as the full-time responsibility of a specialist. The person selected for this position must be one who can maintain the confidence of the personnel and be delegated to act for the management on all personnel matters rather than be merely a buffer between management and employees.

The authority of hiring and dismissing employees, however, should remain vested in the engineering executives in order to permit their continued exercise of complete control over their personnel. In no case should the personnel office make decisions regarding personnel complaints without first reviewing the matter with the executive and supervisor affected.

BASIC ENGINEERING ORGANIZATION

The departmental functions shown in Fig. 1:1 can be readily converted into a basic engineering-organization chart. This is shown in Fig. 1:2, where a small engineering department is organized on the basis of four executives who report to the chief engineer. The number of executives reporting to the chief engineer should be kept to the absolute minimum in all cases, to avoid his becoming so enmeshed in details that he is unable to devote sufficient time to major issues.

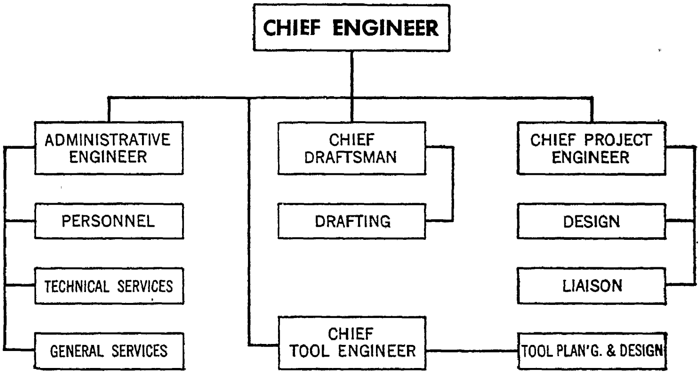


FIG. 1:2.—Functional plan for small engineering department.

The basic principle of organizing any activity revolves around the establishment of a staff of executives who carry out the operations and are directly responsible to the management. Engineering management is represented by the chief engineer, and while the department is very small, it is possible for the chief engineer to direct personally the operation of all functions. But as the department increases in size, this no longer remains feasible, the growth resulting in too much responsibility for one person, too many details, too many decisions. The chief engineer who insists upon carrying the entire load will soon find it increasingly difficult to concentrate on the matters at hand, difficult to make even simple decisions. The chief will become uncertain of himself and correspondingly irritable. This mood will infect those in contact with the chief engineer and will spread throughout the department, resulting in a general deterioration of morale.

LINE ORGANIZATION

The solution is not difficult and involves simply application of the military principle of line organization with a staff command. Instead of

the department's operating as a one-man organization, it then functions as a group of coordinated functional subdivisions, each managed by an executive acting with the chief engineer's authority on certain delegated functions.

These executives are selected and retained for their ability to apply the chief engineer's policies to each situation and arrive at substantially the decision that the chief himself might have made. The chief engineer is then free to devote undivided attention to developing and perfecting policy and to deal thoroughly with new problems referred to him for solution by the executives. The same general policy should be followed with the supervisors responsible to the executives.

Application of the principle of staff command to an engineering organization not only is important from the viewpoint of the chief engineer but is also vitally important to the company as a whole. For with this type of organization the company may feel secure in the knowledge that should the department head become incapacitated, the executives would be fully qualified to carry on until a suitable replacement could be found.

After an executive staff has been established to operate an engineering department, it is necessary to inaugurate the practice of regular, scheduled meetings of the chief engineer and his staff. At these meetings progress reports can be reviewed, budgetary matters discussed, policy corrected, and all special problems studied and solved. This avoids the reevolution of a dictatorial management where orders and decisions are arbitrarily handed down by the chief engineer and insures the workability of a staff command organization. A similar practice of regular scheduled meetings among each executive and his supervisors should precede the staff meetings.

"GENERAL STAFF" FOR SMALL ENGINEERING DEPARTMENT

The four executives shown in the chart of Fig. 1:2 are an adequate "general staff" for a small engineering department. To each is delegated the authority to accomplish certain basic functions necessary for the successful operation of the department. Design and liaison functions become the responsibility of a *chief project engineer*, who is provided with a project engineer to supervise design and liaison on each current project. A *chief draftsman* supervises all drafting activities, including production engineering. Drafting personnel are responsible to the project engineers on matters relating to design but to the chief draftsman on other matters. An *administrative engineer* directs all engineering services and controls personnel matters.

The chief project engineer, chief draftsman, and administrative engineer form a basic staff. In some cases it may be advantageous to expand this staff to include a *chief tool engineer*, as shown on Fig. 1:2. In relatively small organizations, where the tool engineering group will also be small, this is usually a wise action. It insures close coordination between design and tooling work, with the result that the completed design will be practical of manufacture. The release of tooling is greatly

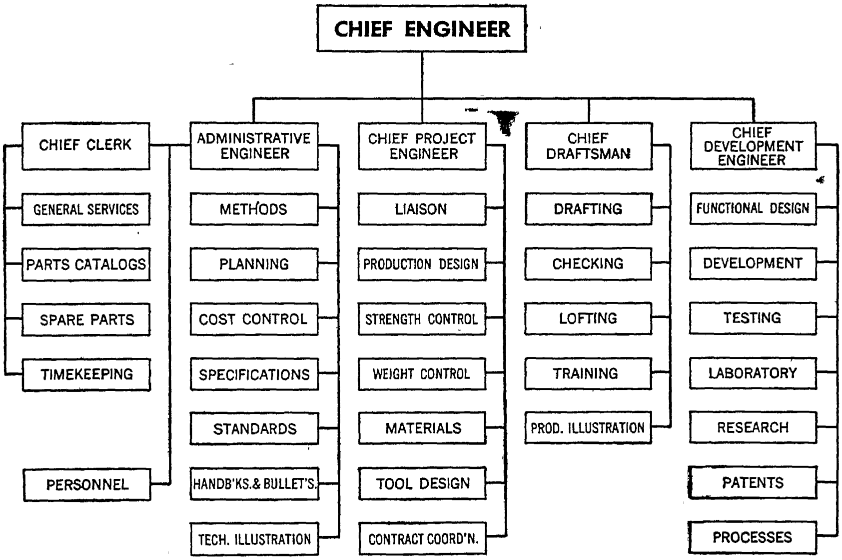


FIG. 1:3.—Functional plan for large engineering department.

accelerated, as the tool engineers are able to design preliminary tooling concurrently with development of the preliminary product design.

ORGANIZATION FOR LARGE ENGINEERING DEPARTMENT

In Fig. 1:3 is shown a functional pattern suitable for a large engineering department. The chief project engineer, chief draftsman, and administrative engineer remain on the basic staff, and the position of *chief development engineer* has been added. This relieves the chief project engineer to concentrate upon production design. Functional design becomes the responsibility of the chief development engineer.

The position of *chief clerk* is established. This relieves the administrative engineer of direct responsibility for strictly clerical functions. Personnel matters demand the full-time attention of a capable person, and this becomes a separate function responsible to the administrative engineer.

Engineering coordination is handled by the planning group, which is established as a separate function responsible to the administrative engineer's office. Coordination serves a dual purpose: relieving the administrative engineer of the burden of correspondence follow-up and ascertaining the fulfillment of all engineering contractual obligations. Incoming correspondence is routed to the coordinator, who ascertains the effect of each and forwards copies to the persons affected with a definite statement of the action to be taken. Follow-up is maintained to insure prompt and proper reply to correspondence. A detailed record is kept of all contractual obligations, and those concerned are informed regarding their part in the fulfillment. The administrative engineer is kept aware of all progress and deficiencies.

ORGANIZATION OF DIVISION ENGINEERING DEPARTMENTS

The value of a staff command organization becomes increasingly apparent as the magnitude of engineering activities increases. The establishment of an engineering organization for a corporation having several operating divisions, as shown in Fig. 1:4, would be an impossibility unless handled in this manner.

The preceding outline of functional organization was based upon the requirements of the engineering department of a self-contained company. When the company has two or more operating divisions, each with its own engineering department, the problem becomes more complex. Different functional organization is required to provide corporate control over the engineering departments at the operating divisions.

A basic engineering organization suitable for a corporation with several operating divisions is shown in Fig. 1:4. Each division engineering department is managed by a division chief engineer and provided with a basic staff comprising a chief project engineer, chief draftsman, and administrative engineer. The detail organization of the division engineering departments is shown in Fig. 1:8.

The corporate engineering structure for all divisions is headed by a vice-president in charge of engineering, assisted by a chief administrative engineer and a chief development engineer. To avoid having the division chief engineers continually frustrated by dual responsibility, it is necessary to define their duties clearly to both the engineering vice-president and their respective division managers in a manner that avoids overlap and conflict.

Each division chief engineer is basically responsible to the division manager on all matters peculiar to division operation. On the other hand, the vice-president in charge of engineering, being responsible for

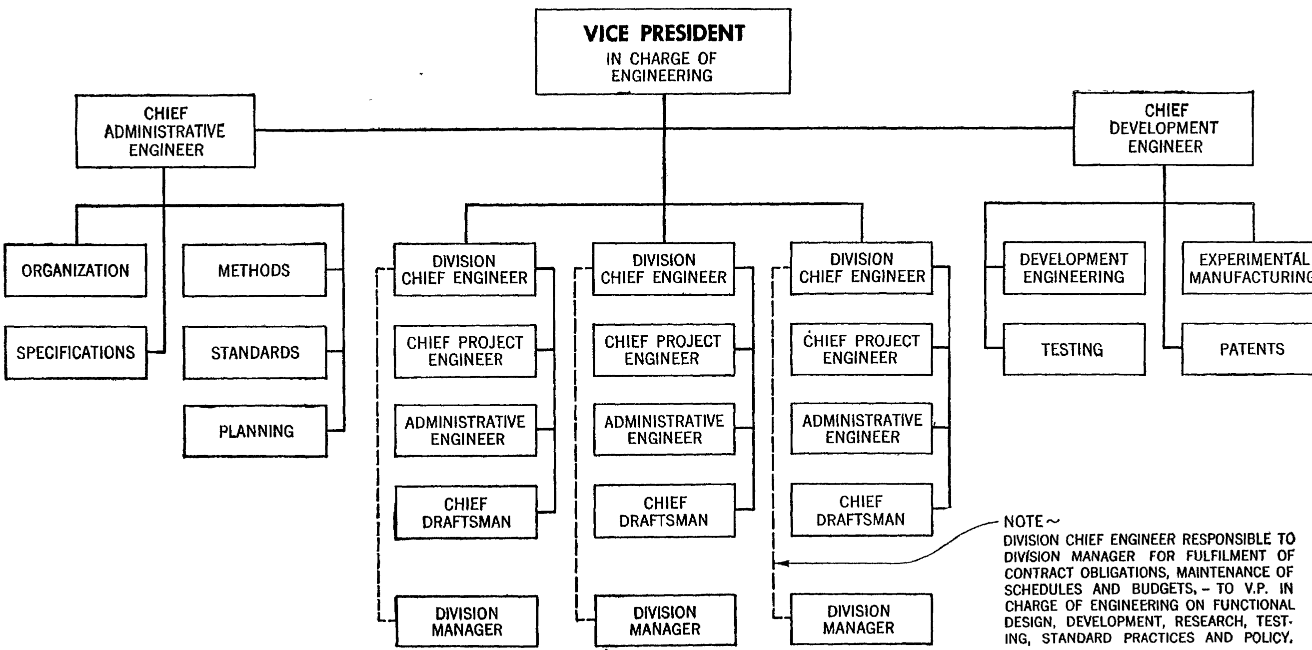


FIG. 1:4.—Functional engineering plan for corporation with several divisions.

the over-all operation of all engineering activities, must maintain control over those matters affecting *all* division engineering departments.

The division chief engineer is responsible to the division manager for the fulfillment of contractual obligations, for production design, and for maintenance of schedules and budgets and to the engineering vice-president for functional design, development, research, testing, standard practices, and policy.

Functions affecting the operation of all divisions, irrespective of the products manufactured by each, are directed by corporation executives responsible to the vice-president in charge of engineering. All development engineering, including experimental manufacturing, is handled by the chief development engineer. Division chief engineers requiring development, research, or testing have this work accomplished by the corporation, under direction of the chief development engineer. All new designs are originated by the chief development engineer's organization and then transferred to a division for production engineering and manufacture.

The administrative functions that affect all divisions are directed by the chief administrative engineer. Important among these are methods and standards, planned so as to insure uniform practices in all division engineering departments and to prevent duplication of work. Model specifications relating to the products manufactured by the divisions are handled by the chief administrative engineer, as is the necessary planning to insure meeting all contractual obligations.

DETAIL ORGANIZATION

In Figs. 1:5 and 1:6 will be found detailed organization plans suitable for small engineering departments and based upon the functional organization shown in Fig. 1:2. Figure 1:6 shows an engineering organization suitable for a small aircraft-manufacturing company. All development *and* production engineering is the responsibility of the chief project engineer.

GROUP SYSTEM

The group system is used where the major structure and equipment components of the airplane (such as wing, fuselage, and armament) are each handled by a design and drafting group working under the direct supervision of a group leader. Project engineers for the various models or projects under design and construction provide general supervision.

The group supervisors and, in turn, the personnel of each group are responsible to the project engineers on all matters relating to design and

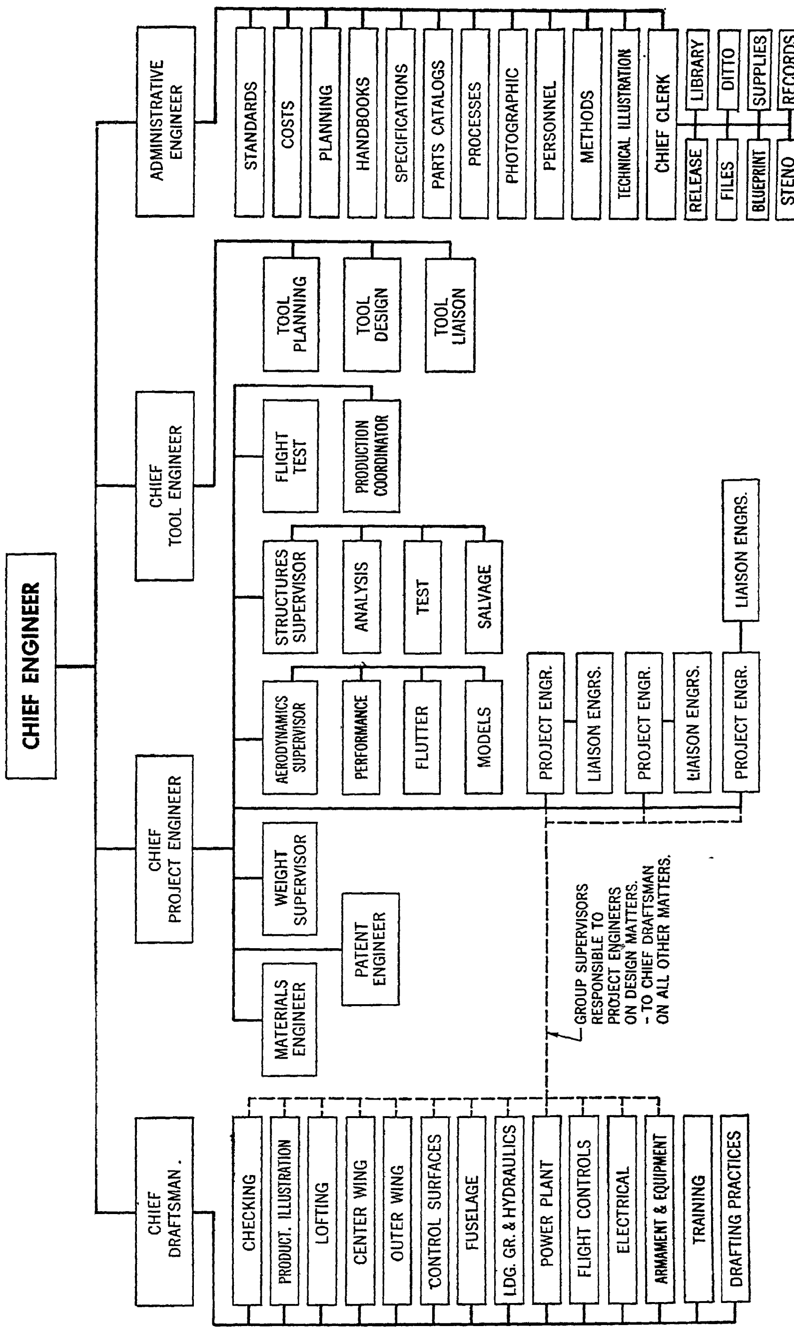


FIG. 1:5.—Organization of small engineering department (aircraft).

to the chief draftsman in all other matters—such as allocation of personnel, assignment of work, and general discipline and deportment.

PROJECT SYSTEM

The engineering organization shown in Fig. 1:6 is suitable for firms involved in the design and manufacture of mechanical or electronic

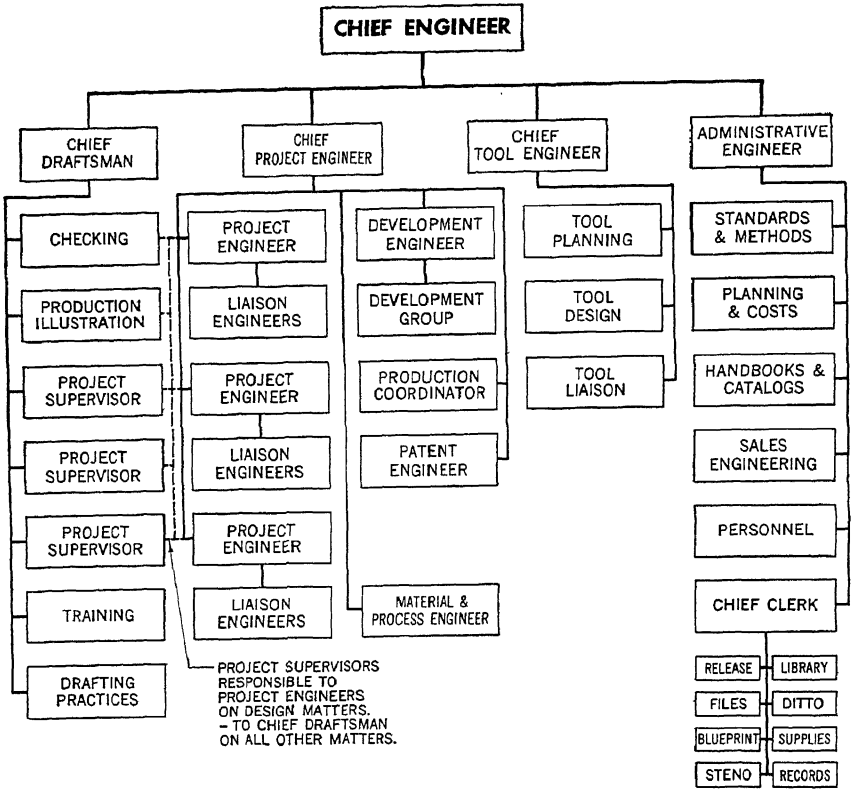


FIG. 1:6.—Organization of small engineering department (machine design).

devices. A less complex product is assumed, and the component-design groups are replaced by project-design groups. The group supervisors have been replaced by *project supervisors*, who are each responsible for a design and drafting group delegated to accomplish all engineering on a given project. Structures and weights specialists are eliminated, on the basis that stress analysis and weight control will be accomplished within each project group as a responsibility of the project supervisor.

A development group has been added to the chief project engineer's office to handle development, research, and testing. The functions of the administrative engineer have been simplified, on the basis that the manufacture of a less complex product will permit consolidation of some functions and elimination of others.

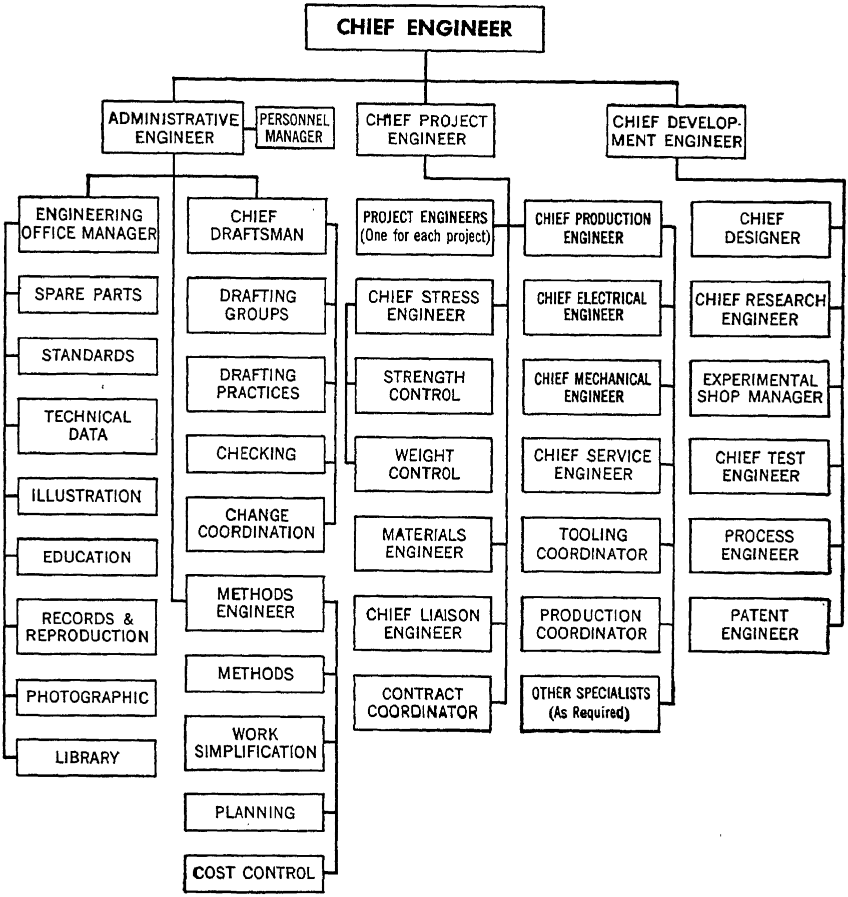


FIG. 1:7.—Organization of large engineering department.

LARGE DEPARTMENT REQUIRES DIFFERENT ORGANIZATION

When the engineering department increases in size, it will be found that the simple organizations shown in Figs. 1:5 and 1:6 are no longer adequate for efficient operation. It becomes necessary to consolidate certain functions and further subdivide others. This involves a rear-

rangement, rather than change, in the basic functional organization. A suitable arrangement for a large engineering department is shown at Fig. 1:7.

As the engineering work increases in magnitude and complexity, it is necessary to reduce the number of executives reporting directly to the

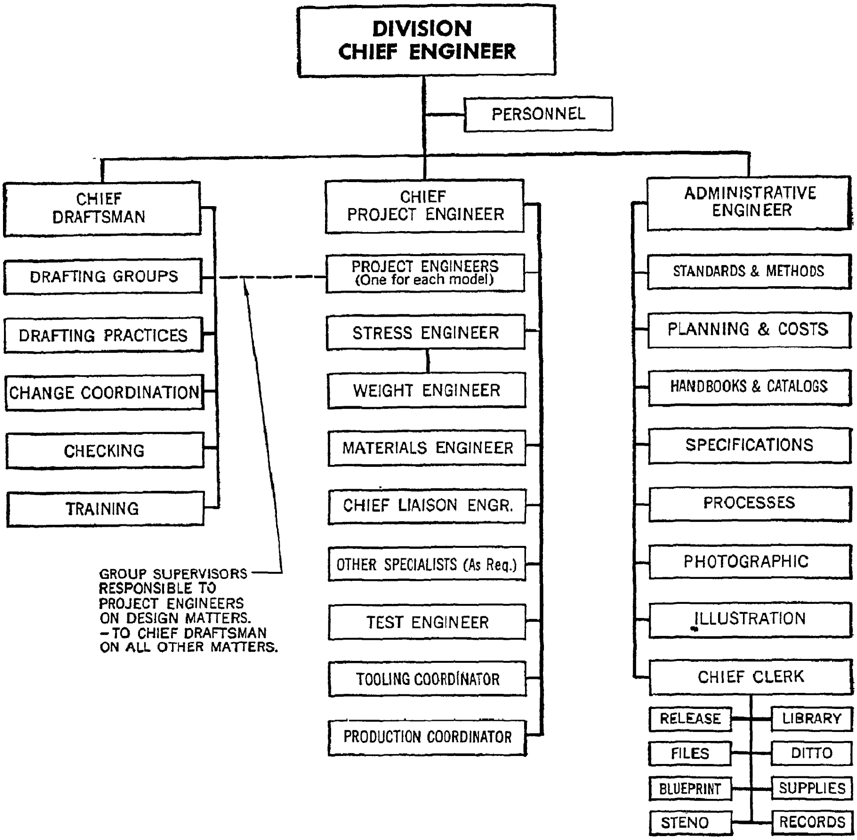


FIG. 1:8.—Organization of division engineering department.

chief engineer. Unless this is done, the chief engineer's time will be largely consumed by the reports and problems of a host of subordinates. This problem is solved in the organization shown in Fig. 1:7 where one executive is placed in control of each of the three prime functions: production design, functional design, and departmental operation.

The chief development engineer handles all matters relating to functional design while the chief project engineer directs all phases of production design. The administrative engineer is responsible for all opera-

tional phases of the engineering department and, in general, becomes the business manager of the department. This comparatively simple arrangement provides that the chief engineer receive reports from but three people.

ASSISTANT CHIEF ENGINEER

The organization arrangements shown in Figs. 1:1 through 1:8 do not provide for an assistant chief engineer or for assistants to the other executives. These can be established as needed to relieve executives of burdensome detail work. In the case of an assistant chief engineer, this position can be considered analogous to a "chief of staff" who conveys the chief engineer's instructions to the top executives forming the "staff command" and makes certain that each properly executes his portion of the program.

LINE AUTHORITY

After an engineering organization is established, certain basic principles of management must be followed in order to insure its proper operation. Again we can borrow a military expression to illustrate the point and say that it is necessary for all instructions, complaints, and assignments to "go through channels." All must flow along the established lines of authority, and in no case should any member of the engineering department pass over a superior or subordinate when transmitting instructions, complaints, or assignments.

Unless this policy is scrupulously observed on the part of the executives and supervisors and rigidly enforced upon the part of employees, it is impossible to maintain morale and discipline within the department. The employee must first take all problems to his immediate supervisor and must in every case receive his instructions from the same person if he is to have the proper respect for the supervisor.

Employees should not receive from an executive of the department decisions upon matters under the jurisdiction of supervisors—instead they should be immediately referred back to their supervisor. On the other hand, the executive who issues instructions directly to the employees of a supervisor (even though subordinate to the executive) is guilty of a cardinal error. Such practices destroy the supervisor's prestige, with resultant deterioration of departmental morale.

DUTIES OF ENGINEERING PERSONNEL

The duties of the various executives, supervisors, and personnel groups shown in Figs. 1:5 through 1:8 are defined in the subparagraphs following. The definitions are generally applicable to any engineering depart-

ment but may require occasional modification to suit individual conditions present in a given company. Many of the job titles have been arbitrarily chosen on the basis of being most descriptive of the job functions. It should be understood that basic functional organization is the important matter and that the job title is of minor significance. For example, the functions delegated here to the administrative engineer could be carried out equally well by an "executive engineer" or "engineering manager," *but in each case the basic functions will remain the same, regardless of job title.*

Vice-President in Charge of Engineering:

Establishment of engineering policy. Final approval of functional design of new models and major changes in existing models. Contact between company and customer on matters affecting engineering policy and/or contractual obligations.

Chief Engineer:

Direction of engineering activities. Consultant and final approval on majority of design problems referred from chief project engineer and chief development engineer. Responsible to management for maintenance of engineering schedules and budgets and satisfactory accomplishment of contractual engineering requirements.

Chief Project Engineer:

Direction of production design on all engineering projects. Approval of all new design and major changes in existing design.

Chief Draftsman:

General direction of all drafting supervisors, draftsmen, and other hourly employees on matters involving discipline and/or deportment. Allocation of personnel as required to meet work schedules. Application of methods and drafting practices as established by standard-practice instructions. Work assignment to supervisors directly responsible to chief draftsman's office. General supervision of apprentice draftsmen.

Chief Development Engineer:

Direction of functional design, research, and testing for all engineering projects. Director of experimental shop. Patent investigation and process development.

Chief Tool Engineer:

Direction of tool planning, design, and liaison. Direction of tool-manufacturing department.

Administrative Engineer:

Direction of general engineering office management, arrangements for business trips, and approval of expense accounts. Direction of technical and clerical groups and personnel management.

Engineering Personnel Manager:

Wage and salary administration. Procurement of engineering employees. Interviews with prospective employees. Maintenance of employee histories. Terminations. Vacations and leaves of absence.

Project Engineer (for each project):

Supervision of production design and liaison engineering on a given project or group of related projects. Maintenance of engineering schedule governing project. Accomplishment of contractual engineering requirements relating to project.

Aerodynamics Supervisor:

Direction or supervision of wind-tunnel models and tests, performance calculations, flutter analysis, and general aerodynamic research. Establishment of flight-test requirements and interpretation of results. Development of control surfaces and investigation of stability and handling in general. Consultant on design.

Structures Supervisor:

Direction or supervision of structural analysis, static test, and engineering authorization for parts salvage. Final authority for strength of parts. Consultant on design.

Flight-test Engineer:

Supervision of all flight testing. Practical application and testing of aerodynamic research.

Weights Supervisor:

Estimated, calculated, and actual weights on all parts. Weight and balance investigations and reports. Weight control. Consultant on design.

Materials Engineer:

Material requirements for new models, sources and availability of materials. Issues advance engineering material orders to procure materials required.

Chief Production Engineer:

Direction of production design. Supervisor of production-design specialists. Coordination of design with tooling, production, and service departments in order to reduce manufacturing costs and improve product.

Methods Engineer:

Engineering methods and drafting practices. Engineering planning and cost control. Work simplification.

Chief Checker:

Accuracy of drawings and conformance to methods and drafting practices. Production design. Supervisor of company checkers and inspector of work accomplished by checkers supplied by professional engineering firms. Coordination of engineering and loft checking.

Illustration Supervisor:

Supervision of all art and perspective drawing required by the engineering department. Preparation of production-line, catalogue, and handbook illustrations scheduled for each project.

Loft Supervisor:

Supervision of all lines and template development (but not actual template manufacture) scheduled for each project.

Design Group Supervisor (one for each design group):

Supervisor of draftsmen in a given design group, including design and drafting practices, engineering procedures, and personnel control but excluding allocation of personnel. Approval of all drawings originating in group. Responsible for production design and shop engineering relating to group. Maintenance of group records.

Project Supervisor (one for each project):

Supervisor of drafting and design relating to a given project, including drafting practices, engineering procedure, and personnel control but excluding allocation of personnel. Approval of all drawings originating in project group. Responsible for production design and shop engineering relating to project. Maintenance of project records.

Chief Clerk:

Direction of release, blueprint, ditto, photographic, engineering file, and library groups. Procurement of engineering department supplies. Direction of engineering secretaries and stenographers.

Standards Engineer:

Company representative on government and industry standards committees. Development of company standard parts and designs. Maintenance of government, industry, and company standards handbooks. Drafting-room manuals and standard-practice handbooks. Maintenance of material- and process-specification files. Consultant on commercial standards and materials.

Planning Engineer:

Works in conjunction with chief project engineer, chief development engineer, chief draftsman, costs engineer, and group supervisors to schedule engineering work on each project and to maintain records of engineering expenditures and accomplishment. Preparation of work schedules and time estimates needed to complete work within contractural requirements, weekly reestimates of time on basis of percentage complete, and initiation of necessary changes in personnel and work assignments needed to complete jobs by required dates. Control of all correspondence between engineering and customers. Dissemination of information on all contract changes and deviations. Maintenance of records of contractual requirements and compliance thereto and of records of all specification deviations and customer-request changes. Control of all requests for data, incoming and outgoing.

Costs Engineer:

Maintenance of balance between functional design and sound business methods. Maintenance of cost records for department, warning executives and supervisors when expenditures are nearing budget limits. Establishment of budgets. Comparative costs of engineering design to determine most economical manufacturing methods. In large departments certain of these functions are transferred to the chief production engineer, and the cost engineer's work becomes largely a matter of budgetary control.

Handbook Engineer:

Preparation of all handbooks of instruction, parts catalogues, and service bulletins.

Specifications Engineer:

Preparation of all specifications relating to company products.

Educational Supervisor:

Training of new employees for engineering department. Specialized education of existing employees.

Process Engineer:

Process and finish specifications. Development of new processes. Consultant on all matters relating to manufacturing or finishing processes.

Assistant Project Engineer (for each project):

Detail design and shop engineering matters pertaining to project. Supervision of liaison between factory and engineering on project. Direction of group supervisors on drafting and design relating to project (except drafting practices, personnel allocation, and control). Coordination of design between groups.

Liaison Engineer (one or more for each project):

Interpretation of drawings and expediting the exchange of information between engineering and factory. Shop engineering to facilitate manufacture.

Layout Draftsmen:

Development of designs. Preparation of manufacturing drawings. Guidance of detail draftsmen.

Detail Draftsmen:

Preparation of manufacturing drawings.

Stenographic Supervisor:

Supervision of all engineering department secretaries and stenographers. Assignment of work to stenographers not assigned to a specific full-time duty.

Many of the executive and supervisory classifications listed here could be broken down into several levels of subordinate positions. This has been done only in the case of group supervisors, where classifications of layout draftsman and detail draftsman have been listed. To attempt breaking each supervisory classification into its senior and junior subordinates, with an indication of the various related technical and clerical positions, would require an extensive listing and serve no useful purpose.

ORGANIZATION CHARTS

It may seem that issuance of an actual, physical organization chart of the engineering department is relatively unimportant. This is not true. In fact, one of the most important steps in establishing a smoothly func-

tioning department is the issuance of an organization chart, followed by immediate revisions whenever personnel or functional changes become necessary. When this is done, there can be no misunderstanding regarding the authority and responsibility of the various executives and supervisors. The departmental morale is greatly strengthened by the public announcement of the status of each person in the department.

Concurrent with the issuance of an organization chart there should be distributed a brief statement defining the authority and responsibility of each person shown thereon. This can be similar to the examples shown on pages 17-22 and will clarify the status of each person in the department beyond all possibility of misunderstanding. The importance of these simple steps must not be underestimated. Nothing is more deleterious to departmental morale than uncertainty regarding responsibility and authority.

In conclusion, the essence of engineering organization involves determination of the functions involved; allocation of these functions to a *small* staff of competent executives, who each direct a group of supervisors; followed by a clear-cut organizational scheme based upon positively defined duties and authority.

CHAPTER 2
OPERATION

Following organization of the engineering department there arises the necessity of formulating an operating program. This should not be confused with establishment of drafting practices and operational procedure. Instead, it concerns establishing a program for product development, the operation of engineering as a unit of the company, and its relation to other units.

Engineering's basic function is the development of products that can be profitably manufactured and marketed. Its duties encompass development of these products, followed by preparation of drawings defining the finished articles. These drawings do not necessarily describe all manufacturing and subassembly operations required to fabricate the article but must show the *finished* form of each part and assembly for design and inspection purposes.

Thus it becomes apparent that Engineering is actually a service group, supplying other departments with basic information required for product manufacture. Engineering should never overlook its service capacity and must maintain friendly cooperation with all departments of the company. It may be true that other departments could not operate without Engineering's output of information, but it is equally true that Engineering would be valueless in the absence of manufacturing facilities.

ENGINEERING PROGRAM

An engineering program represents a planned effort to develop new products, improve existing products, reduce manufacturing costs, and exploit patent rights. The nature of the program is established by company top management through evaluation of markets, products, finance, and facilities to determine profitable new and improved products.

The more important factors governing the development of an engineering program are shown graphically in Fig. 2:1. The department heads primarily concerned with supplying company management with information required to determine the engineering program (and consequently the over-all company program) are the sales manager, chief engineer, treasurer, and works manager. The sales department investigates

market needs, determines detail requirements for products to fill these needs, estimates probable sales volume, and ascertains sales prices compatible with competitive articles.

Engineering supplies the probable cost and time span required for developing new products and the possibilities of improving existing products. Available personnel and facilities must be studied to determine their adequacy for the proposed product development and improvement. The possibilities of reducing manufacturing costs through

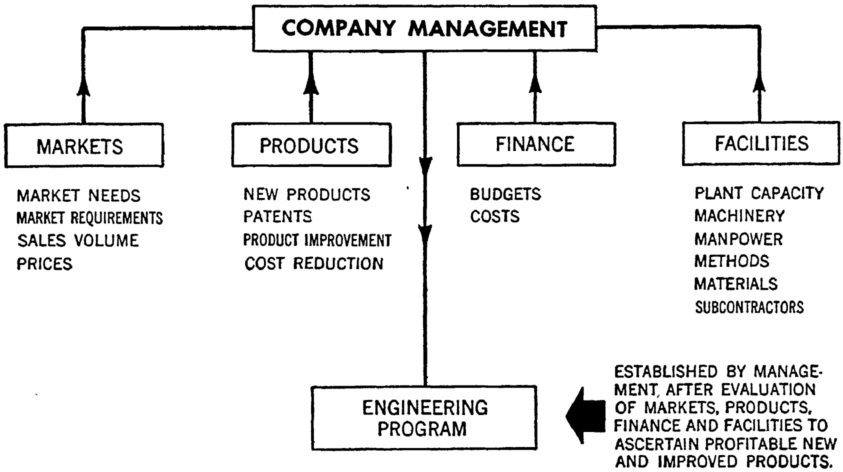


Fig. 2:1.—Factors influencing establishment of engineering program.

product redesign must be evaluated to ensure that sales efforts will not be defeated by lower priced competitive products. The effect of patents should be investigated to insure maximum protection from rights held by the company and to avoid designs that interfere with patents held by others.

The purposes of finance and accounting functions controlled by the treasurer are to estimate the cost of product development and improvement proposals and to ascertain the probable revenue from each. Available manufacturing facilities require careful study during determination of an engineering program. The ability of factory buildings to accommodate the product, machinery available for its fabrication and assembly, obtaining necessary specialized workers, necessity of changing manufacturing methods and plant layout, availability of required materials, and the possibility of profitably subcontracting a portion of the work are items that must be considered.

An engineering program normally comprises two phases: (1) development engineering and (2) production engineering. The development

program will, of necessity, be somewhat fluid and subject to revision to meet changing market requirements. The production engineering program, on the other hand, should be well crystallized on the basis of long-range production contracts and sales forecasts.

APPLYING THE ENGINEERING PROGRAM

Work begins in the engineering department immediately following establishment of a program or formulation of major changes in an existing program. Detailed budgets and schedules must be developed and man power allocated to each project created by the program. Leaders must be selected for each project. These project engineers should be thoroughly informed in the purpose of their projects and provided with adequate specialized and general personnel to permit successful realization of their goals.

When concurrent development and production engineering are in process, it is desirable to assign separate personnel to each phase, but not to the extent of physically segregating the development activities. Such a policy renders coordination between development and production engineering very difficult. In large departments it is feasible to have key personnel permanently assigned to development engineering and other competent engineers established on production projects. This condition is rarely possible in a small engineering department, and it is necessary to assign a qualified engineer to lead the project through the development stage and early production life of the article. When all major production problems have been solved, the remaining routine engineering can be entrusted to a liaison engineer, and the design engineer assigned to new product development.

Weekly meetings should be held among the chief project engineer and his staff of project engineers and group leaders to discuss design and operation problems. Each of these meetings should be followed by a meeting of the chief engineer and his staff executives to consider policy matters and means of expediting the engineering program. All present at the meetings should be encouraged to discuss their complaints and problems. In every case the chief engineer must provide a speedy decision on matters hampering project progress.

DEVELOPMENT ENGINEERING

Development engineering is the creation of product designs capable of executing the required functions and possible of construction within allowable manufacturing costs. A test model is usually built as part of

the development program, and sometimes an actual prototype article is constructed, or even a pilot production run for service-test purposes. The production-engineering phase begins immediately after the design is proved functionally correct. In large engineering departments the design is often transferred at this point to a production project engineer, and the development engineer ceases to participate actively in its promotion.

The production engineer translates the functional, experimental design into its most practical production form. This process involves investigating the manufacturing economy of all detail parts, assemblies, and installations and the achievement of this economy without introducing changes that compromise the design's functional efficiency.

The time required for production engineering is greatly reduced when production requirements are considered during development of the design. Close coordination between development and production engineering will avoid designs that are functionally ideal but virtually impossible to manufacture. All development personnel should give due consideration to production requirements. The tooling and manufacturing-planning departments should be fully informed of all development projects and consideration given their advice regarding adaptability of the design to economical tooling and manufacture.

Close coordination must be maintained between development engineering and the sales department in order to insure the creation of a product that meets customer requirements. Changing customer requirements or market trends often cause frequent revisions during the development of a product. These should be accepted gracefully, even though very annoying. It must be remembered that the product is being designed for profitable sale, not to gratify the creative ability of the engineering department.

PRODUCTION ENGINEERING

The production-engineering phase does not cease with initial release of a complete set of production drawings for an article. Cost reduction and liaison must continue throughout its production. Engineering must be constantly alert to recognize improvements that become apparent only during manufacture. Many worth-while suggestions for cost reduction and product improvement will be received from other departments. An effort should be made to encourage these suggestions, and a friendly reception afforded each regardless of its merit. The person making an absurd suggestion today may conceive a valuable improvement tomorrow. If today's recommendation is greeted with scorn, it is unlikely that additional suggestions will be received.

It is vitally important that the originators of usable cost-reduction ideas receive due recognition when their suggestions are adopted. Nothing could be less desirable than the belief that Engineering uses suggestions and ideas of others to enhance its own position. Many companies have a cost-improvement suggestion program where all suggestions are forwarded to a committee for consideration, followed by financial rewards to originators of money-saving ideas.

Engineering Liaison

Production engineering must maintain efficient liaison with all departments affected by engineering information. Frequent requests for additional information, interpretation of existing information, drawing changes to facilitate the work of other departments, and drawing deviations to permit use of improperly manufactured parts or substitute materials are among the problems that arise. Proper handling of engineering liaison is the foundation of amiable relations between Engineering and other departments.

Drawing change and deviation requests should be considered fairly and granted when the integrity of the product is not compromised. Engineering must not refuse change or deviation requests on the grounds that "engineering drawings must be followed" or that "if the shop does its work properly, there will be no need for drawing deviations." Although both statements may be correct, it profits no one to insist upon complicated, expensive manufacturing methods or the scrapping of usable parts. It is well to remember that the unavoidable presence of incidental drawing errors indicates that other departments should not be criticized for occasional mistakes.

When Engineering fails to cooperate cheerfully in simplifying manufacturing operations and minimizing scrapped parts, it falls short in its duty of creating and maintaining products that insure profitable operation. On the other hand, Engineering must firmly refuse changes that adversely affect the product and the use of parts that are certain to cause unsatisfactory operation.

RELATION OF ENGINEERING TO OTHER DEPARTMENTS

Engineering is the source of product information; it forwards all basic manufacturing and sales data to departments concerned with fabrication, inspection, and marketing. Paralleling this flow of outgoing information is a stream of incoming requests for additional data. Many of these originate from problems arising during application of the initial

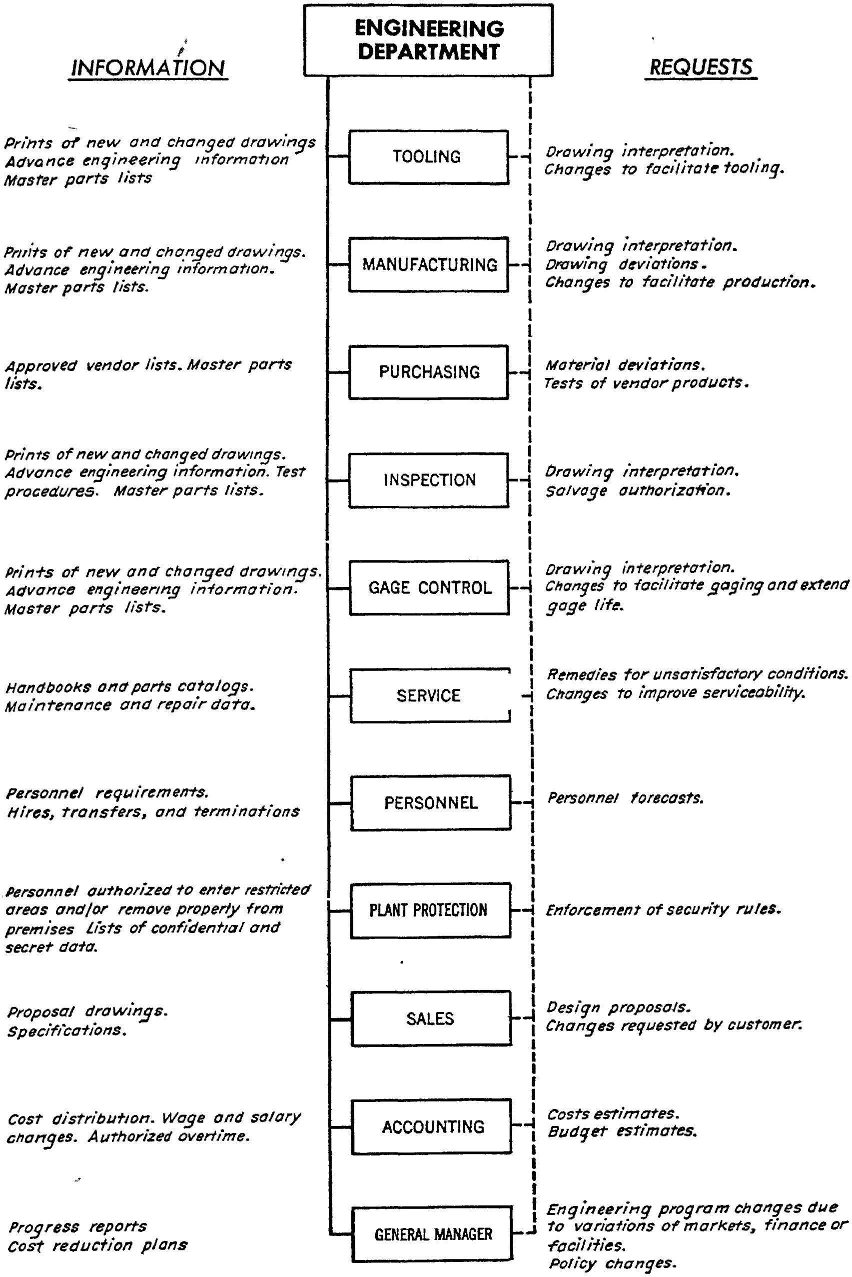


FIG. 2:2.—Relationship of engineering to other departments.

engineering releases. The general relationship is shown in Fig. 2:2, which lists basic engineering-information releases and normal requests for additional data. It is also true that Engineering frequently requests and/or receives information from other departments. These secondary affinities are not shown.

The activities directly concerned with production are tooling, manufacturing (which includes planning, material control, fabrication, and assembly), gauge-control, and inspection. Engineering supplies each with identical basic information. These releases normally involve prints of all new and changed drawings, together with advance information regarding new designs and changes. Requests for drawing interpretation are frequently received from these activities. Data that appear exceptionally lucid to Engineering may be obscure to the recipient, owing to incomplete engineering releases or deficient drawings.

Drawing-change and Deviation Requests

A majority of drawing-change requests originate with tooling, manufacturing, and inspection activities. These deserve careful consideration, as the requesters are thoroughly familiar with production possibilities and limitations. Requests that reduce tooling costs or permit use of improved tooling should receive particular notice. The success of a production article is greatly influenced by its adaptability to interchangeable manufacture with economical tooling. On the other hand these departments rarely are fully conversant with design limitations and often request changes that cannot be granted. A full explanation of the reason should be furnished in these cases.

The manufacturing departments may occasionally produce parts deviating from drawing dimensions in a manner that cannot be reworked and request a deviation to authorize their use, or they may discover that a certain material cannot be procured in time to meet production schedules and request permission to use a substitute. In the former case it is well to remember that incorrect parts are not intentional and that scrapping these will cause an additional production run with resultant reissue of shop orders and rescheduling. However, parts that cannot be used with safety must be scrapped.

Scrap resulting from improperly manufactured parts can be greatly minimized by intelligent selection of dimensional tolerances during design. In no case should the absolute maximum limits be specified for drawing dimensions. When absolute values are used, all parts not manufactured within drawing limits are scrap, unless the error permits re-

working to limits. Instead, limits appearing on the drawing should represent about 75 per cent of the absolute values. The remainder is a "cushion" that will permit acceptance of many cases of improperly manufactured parts as a deviation or salvage.

Inspection Disposition of Rejected Parts

Inspection is charged with the responsibility of maintaining product integrity by insuring that all parts are fabricated and assembled in conformance with applicable engineering drawings and specifications. Parts which deviate from engineering requirements but which are obviously reworkable to drawing limits are frequently discovered. These are normally rejected to the originating department for rework and do not affect Engineering. When the cost of rework is out of proportion to the magnitude of the defect and Inspection considers the part usable without rework, a drawing deviation is requested. Parts that can be neither reworked nor accepted as deviations are held for salvage disposition.

Meetings are held to examine parts held for salvage disposition. Representatives of Engineering and Inspection and sometimes the customer are present. Three courses of action are possible: The parts can be scrapped, used without rework, or a special rework procedure can be devised. Usage of the parts requires unanimous agreement of the salvage committee, and all salvaged parts are identified by special markings. Inspection has full authority to scrap parts considered unsuitable, irrespective of the viewpoints of other members of the salvage committee. This prerogative must be vested in inspection in order that responsibility will be accepted by that department for maintaining product integrity.

Gauge-control Functions

The gauge-control department directs manufacture and use of all gauges employed to maintain interchangeability. It is sometimes a subdepartment responsible to engineering. A majority of gauging involves the control of dimensional limits of mating cylindrical parts, and plain and threaded-plug and ring gauges are used. Three types of gauges are usually maintained: production, inspection, and basic.

Production gauges produce parts to limits slightly less than the drawing limits. The corresponding inspection gauge will accept a part within the full dimensional limits, insuring that parts produced to the production gauge will be accepted at inspection. Basic gauges check the nominal dimension and are used to verify dubious cases.

Use of the three types can be illustrated by the gauges suitable for a tapped hole. The production threaded-plug go gauge should be new, containing the maximum wear allowance and consequently larger than the thread basic-pitch diameter. The inspection go gauge should be very close to the pitch diameter and is probably a worn gauge retired from production checking. The basic gauge is exactly on the basic-pitch diameter. Thus a tapped hole that receives the production go gauge will be slightly larger than the basic-pitch diameter, insuring that the inspection go gauge will fully engage and that the basic gauge can be inserted with ease. Unless this relationship is maintained, friction will arise between Inspection and Manufacturing from rejection of parts that fit production gauges but fail to accept corresponding inspection gauges.

Effective Serial Numbers for Changes

A serial number is usually assigned to each article for identification during manufacture and subsequent service life. All production planning and scheduling are based upon the serial numbers of articles to be manufactured during specified periods. Among the data frequently requested by Engineering is establishment of effective serial numbers for drawing changes. All drawing changes, except mandatory changes due to product deficiency, should become effective at the convenience of Manufacturing Planning. Confirmation of the effective serial number should be obtained from Manufacturing before the drawing change is released. Attempts to proceed otherwise will result in turmoil, friction, and needless expense.

Determination of the earliest practicable point at which a change can become effective without upsetting production schedules requires knowledge of completed parts in stores, parts in process at the factory and subcontractors, and the time required before changed parts can be available for assembly. Manufacturing Planning has this information available and is the only group in a position readily to establish production-convenience change points.

Only a few highlights of interdepartmental relationships affecting engineering have been considered here, as a majority of those shown in Fig. 2:2 are self-explanatory. Details will vary greatly with different companies, owing to variations in company organizational structure and personalities. In each case the problem is one of maintaining direction of product integrity without antagonizing other departments.

SELECTION OF ENGINEERING METHODS

The basic methods that must be established to insure successful operation of an engineering department involve control of

Personnel
Costs
Planning
Drafting practices
Drawing and report numbering
Drawing release
Drawing and print control
Advance information
Drawing change requests and drawing changes
Liaison with manufacturing departments

These are considered in following chapters giving practical, proved methods for accomplishment of each. The detail methods given may not be suited to every engineering department, but the general pattern will be applicable in all cases.

Considerable judgment, discretion, and patience are necessary during selection, development, and application of engineering methods. Each proposed method must satisfy all possible contingencies, and its operation must be compatible with existing conditions and facilities. In each case the method must provide a complete record of engineering action without introducing expensive or burdensome complications.

A form of erroneous thinking frequently observed among engineers is the belief that all other considerations can be subordinated to speed during the development of an experimental article. This would be true if the only purpose were completion of a successful prototype. However, *the prime purpose of the development effort is completion of a successful prototype that can be rapidly transformed into a production article.* The transition to production becomes difficult, if not impossible, in the absence of a complete, accurate record of the experimental article.

Compilation of this record requires registry of every operation and change during development of the experimental article. The information must be sufficiently complete to permit a qualified engineer, without prior knowledge of the article, to prepare readily final corrected data describing the exact nature of the completed prototype. In the case of a small organization where the project engineer has complete knowledge of every detail pertaining to a project and experimental manufacturing work is accomplished by a single person or very small group, it is practicable to solve the problem by releasing a set of "master" prints to the person in charge of experimental manufacturing. All changes found

necessary during construction and testing are listed on these prints. These data can be used later to correct the drawings describing the article.

A large organization involving considerable personnel in both the design and construction of an experimental article requires different methods of maintaining project history. It becomes difficult to ensure that all changes are marked on the master prints, and the hazard of their loss increases in proportion to the personnel handling the prints. Therefore, it becomes necessary to provide individual records, in the form of drawing changes, advance drawing changes, or engineering orders, describing each alteration made in the article. These can later be incorporated into their respective drawings to obtain final corrected data accurately describing the completed, tested prototype.

EXPEDITING DEVELOPMENT ENGINEERING

There is little need to prepare a complete set of detail drawings when constructing an experimental prototype article. The variety of changes made during development will usually necessitate redrawing for clarity when production drawings are needed. Thus, the time spent to prepare complete, detail experimental drawings is largely wasted. This is not in contradiction of preceding statements regarding the necessity of maintaining a complete record of development engineering but refers to the appearance and quantity of experimental drawings.

It is good practice to use layout drawings prepared to define the basic design of assemblies for construction of the prototype. This can be accomplished by preparing a duplicate tracing from the layout, assigning this a manufacturing-drawing number, adding necessary materials information and numbers for detail and subassembly parts, followed by release of prints for manufacturing purposes. Sketches issued as advance drawing changes (see Chap. 11) provide information on detail parts that cannot be completely defined on the layout drawing. Precision drafting is not important during preparation of drawings for an experimental drawing; only design and dimensional accuracy are necessary.

When the design proves to be functionally correct and meets all specified requirements, the production drawings can be completed. These will be used throughout the company and should be the product of precision drafting and meticulous checking. Conformance to a standardized drafting system should be rigidly maintained in production drawings in order to facilitate training of manufacturing personnel in ready interpretation of the prints employed in their work.

PROCESSING REQUESTS FOR DATA

Engineering receives requests for data from a variety of sources, and they must be quickly and efficiently answered. A procedure should be

TEST REQUEST

Engineering Laboratory

NOTE: File ALL REQUESTS in TEST JOURNAL
upon completion of tests.

Test Order No.________
Test Engineer________
Report No.________

NAME OF TEST________________

Test Requested by________ Approved________ and________

Date of Request________ Airplane Model________ W. O.________

Test Specimen Drawing No.________ Reference Tests________

OBJECT OF TEST (Summarize):________________

DESCRIPTION OR SKETCH OF DESIRED TEST SETUP:

WITNESS REQUIRED
☐ Air Corps ☐ Navy ☐ Ryan Inspection Others________

TYPE OF REPORT DESIRED
☐ Test Data Memo—For Limited Distribution
☐ Complete Report—For Air Corps, Navy, or General Distribution

DISPOSITION: Test Specimen________ Test Jig________

Authorized by________

ACKNOWLEDGMENT

This test has been assigned Test #________ Priority #________
The final test will be conducted by Mr.________
___on________ 19___

ENG.74 3M 5 43-102

____
DIRECTOR OF LABORATORY

FIG. 2:3.—Test request form used by other departments to request test work by the engineering laboratory.

established to insure that all incoming requests are recorded, acknowledged, and forwarded to the proper destination for answer. A follow-up should be maintained to insure that the answer is forthcoming within a reasonable time. In Chap. 5 it is recommended that processing of all

incoming requests be accomplished by the engineering planning group. When the size of the engineering department does not permit establishment of a separate planning function, the chief engineer should appoint a member of Engineering as the recipient and recorder of all incoming requests and provide means to insure that all requests are forwarded to that person.

All incoming requests should be either immediately answered or acknowledged with a promise of the required information within a specified time. Every effort should be made to provide the information on or before the due date. Nothing is more discrediting to Engineering than a reputation for evasive indecision and failure to provide needed information.

CONTROLLING RELEASE OF DATA

Adequate control must be maintained over all data released by Engineering to ensure the distribution of correct information and the absence of conflicting releases. Drawing release and the control of prints are discussed in Chaps. 9 and 10, and a method of controlling all releases through the engineering planning group is described in Chap. 5. Small engineering departments, where a separate planning function cannot be justified, should vest the control of engineering data releases in the person delegated to handle incoming requests for information.

In all cases it is vitally important to provide means of controlling and recording the release of engineering information, including prints of drawings, copies of advance engineering information, specifications, reports, and correspondence. Unless this control is established and maintained, vexing misunderstandings and expensive mistakes will arise from use of obsolete, erroneous, or conflicting information. Means must be provided to recall and replace obsolete prints, specifications, and reports and to delegate certain personnel as the only source of specified information.

PATENTS

Patents are a vital concern of the engineering department, as it must both avoid unintentional interference with existing patents and obtain full protection for patentable ideas conceived during product development. This phase of engineering is sufficiently important to justify the establishment of the position of patents engineer in any but the smallest engineering department.

The patents engineer investigates all new ideas and developments concerning both product design and manufacturing processes and carries on the activities necessary to obtain required patents and licenses.

CONSOLIDATED VULTEE AIRCRAFT CORPORATION

INVENTION AGREEMENT

AGREEMENT entered into by and between CONSOLIDATED VULTEE AIRCRAFT CORPORATION (hereinafter called the Company), and...(hereinafter called Employee), WITNESSETH:

In consideration of the mutual undertakings hereinafter set forth the parties hereto do hereby agree as follows:

1. The Employee agrees:

(a) To disclose promptly in writing to the Company's Patent Department or to such person as the Company may designate, all inventions and improvements heretofore or hereafter made, developed, perfected, devised or conceived by the Employee either solely or in collaboration with others during the Employee's employment by the Company, whether or not during regular working hours, relating to aircraft or parts and the manufacture thereof, or relating in any way to aviation or to the business, developments or products of the Company; and if so requested by the Company, to assign, transfer and convey to the Company all right, title and interest in and to all such inventions and improvements;

(b) At the request and expense of the Company, to make, execute and deliver any and all application papers, assignments or instruments, and to perform or cause to be performed such other lawful acts as the Company may deem desirable or necessary in making or prosecuting applications, domestic or foreign, for patents and reissues and extensions thereof, and to assist and cooperate (without expense to him) with the Company or its representatives in any controversy or legal proceedings relating to said inventions and improvements, or the patents which may be procured thereon;

(c) To regard and preserve as confidential all information pertaining to the Company's business or that may be obtained by the Employee from specifications, drawings, blue prints, reproductions and other sources, and not to publish or disclose either during the term of employment or subsequent thereto, without the written approval of the Company, such or any other confidential information obtained by the Employee while in the employment of the Company.

2. The Company, if it considers any invention or improvement reported by the Employee pursuant to paragraph 1 hereof to be of substantial value and patentable, will, after completing its investigation in regard thereto, award and pay to the Employee the sum of Ten Dollars ($10.00).

3. The Company, if it elects to acquire any invention or improvement referred to in paragraph 1 hereof, agrees:

(a) To notify the Employee of its election so to do within nine months from the date of the complete disclosure of such invention or improvement to the Company:

(b) To pay all expenses in connection with the preparation and prosecution of patent applications in the United States of America and all foreign countries wherein the Company may desire to obtain patents;

(c) To pay the Employee an additional cash award of Forty Dollars ($40.00) upon execution by Employee of applications for United States letters patent upon such invention or improvement, together with an assignment thereof to the Company;

(d) To pay to the Employee an additional cash award of Fifty Dollars ($50.00) if and when the Company obtains a United States patent on such invention or improvement, it being understood that no such award will be paid to the Employee in connection with the granting of any foreign patent;

(e) To pay to the Employee for each of the Employee's inventions additional compensation consisting of a percentage of any income derived by the Company from any sale of such invention or part thereof, or from any royalties which the Company may collect from licenses to others, including those, if any, in an award by the Manufacturers Aircraft Association, Inc., for the use of such invention, on a sliding scale, as follows:

Of the first $1,000 or part thereof....................	30%
Of the next $1,000 or part thereof	25%
Of any further sums in excess of $2,000..............	20%

4. It is understood and agreed that the obligation of the Company to make payments pursuant to paragraph 3(e) hereof shall continue during the life of any patent subject to this agreement notwithstanding termination of the Employee's employment with the Company, and that in the event of the Employee's decease, such payments will be made to his executors, administrators or representatives.

5. It is further understood and agreed that the Company may sell such invention or improvement, or license the manufacture thereof for such price or royalty as the Company in its sole judgment and discretion shall determine, or if the Company elects so to do, grant royalty-free licenses for the use of such invention, or waive future royalties for a definite or indefinite period of time on any license theretofore issued by the Company on a royalty basis, and that in any of such events, the Employee shall have no claim or claims against the Company, except to receive under the provisions of paragraph 3 (e) hereof the percentages above set forth of such amounts as the Company shall collect through the sale of such invention or improvement or the issuance of licenses to use the same.

6. If the Company shall fail to elect in writing that it desires to prosecute a patent application on any invention or improvement specified in paragraph 1 hereof within nine months following the complete disclosure thereof to the Company, then all rights of the Company in and to such invention or improvement shall revert to the Employee with the exception only that the Company shall have a paid-up non-exclusive license with respect thereto.

7. Neither this agreement nor any benefits hereunder are assignable by the Employee, but the terms and provisions hereof shall inure to the benefit of the Company's successors and assigns.

Dated:

CONSOLIDATED VULTEE AIRCRAFT CORPORATION,

...., 19.........

By...

Witness:

....

....

Employee

Form 758B

FIG. 2:4.—Invention agreement of the profit-sharing type.

All new designs are studied with a view to avoiding interference with existing patents.

Copies of all existing patents relating to company products should be obtained. Study of these patents frequently makes possible the development of completely new, advanced designs—as is so often the case when an old problem is attacked from a completely fresh viewpoint.

Another duty of the patents engineer is encouraging the disclosure of patentable ideas by company employees. There was once a tendency to insist that all patentable ideas conceived by employees were the exclusive property of the company, irrespective of their nature. This policy discourages employee inventions and is being rapidly abandoned. Definitions of the company's "shop rights" to inventions conceived by employees as a direct result of their employment and the inventor's rights to patentable ideas having no relation to his employment have been established. The qualifying factors in this relationship are many and complex, however, and beyond the scope of this discussion.

Even though the company has definite "shop rights" to certain patentable ideas conceived by employees, the unrestricted exercise of this prerogative is certain to circumscribe the development of new and original ideas. Progressive business organizations have discovered that much greater profits result in sharing financial rewards from patents with the employee-inventor, beginning with modest awards upon application for and receipt of the patent and continuing with a percentage of all profits accruing through use of the invention. A typical patent agreement of this nature is shown in Fig. 2:4. The patents engineer is the company representative in such patent profit-sharing plans, and his skill in dealing with employee-inventors governs the success of the patent plan and to a large degree the success of the company—which is greatly influenced by the noncompetitive patent-protected design features present in its products.

CHAPTER 3
PERSONNEL

Administration of the engineering department, as separate from the design and drafting activities, can be divided into two prime phases: business relations and human relations. The latter involves intelligent classification, supervision, and leadership of employees.

Human relations and the technique of handling people deserve constant study by every engineering executive and supervisor—*for a leader can be only as successful as his subordinates permit.* Detailed consideration of the complexities of human relations is beyond the scope of this text, and the reader is referred to the following constructive treatments of the subject:

HEYEL, CARL: "Human-relations Manual for Executives," McGraw-Hill Book Company, Inc., New York, 1939.

SCHELL, ERWIN HASKELL: "The Technique of Executive Control," 4th ed., McGraw-Hill Book Company, Inc., New York, 1934.

MACGREGOR, LESLIE: We'll Need Human Engineers, *Wings*, November, 1944, pp. 1280–1281.

Certain basic policy and procedure must be established for personnel control as the foundation of human relations between supervisor and worker. These can be termed the "mechanics" of personnel control and are considered in this chapter. Few of these are unique to the engineering department but should be understood by all engineering executives and supervisors.

EMPLOYEE MORALE

Departmental efficiency is directly proportional to employee morale, and this is dependent upon an intelligent operating program. Management must be certain that key personnel are fully informed of the nature and purpose of all work in progress and should confirm its confidence in their ability and discretion by delegating to each authority commensurate with his responsibilities. Nothing is more destructive to morale than denying necessary information and authority to subordinates. Even withholding information not strictly necessary for accomplishment of work may be objectionable, for this may produce the belief that engineering management lacks confidence in its executives and supervisors.

Foremost among causes of departmental discord is failure to adhere in all circumstances to the established line of authority. In no case should an engineering executive issue instructions directly to a worker but should either transmit them through the worker's supervisor or request that the worker be temporarily transferred for a special assignment. Everything possible should be done to maintain the position of executives and supervisors. Employees should first refer all complaints and requests to their immediate supervisor. Only when the supervisor is unable to adjust the problem satisfactorily should the worker appeal to engineering management. A worker who ignores this procedure by going directly to management with a problem should be promptly referred to his supervisor, without benefit of immediate decision or adjustment.

STATUS OF SUPERVISORS AND EMPLOYEES

Supervisors must be established as definite leaders of their personnel. The final decision in hiring personnel should be made by the supervisor for whom the employee will work. All recommendations for wage increases should either originate with the supervisor or receive his approval. Each executive should have complete authority to dismiss personnel working under his direction and should heed termination recommendations of his supervisors. This policy places considerable responsibility upon each executive and supervisor and provides the authority necessary to command the respect of their personnel. It will not *insure* the respect of their personnel, for that is gained only by demonstrated ability as a leader. Engineering management must guide and educate each supervisor in proper usage and control of his authority and assist in developing his capacity for leadership.

Management should never criticize a supervisor in the presence of a worker and should normally confirm the supervisor's decisions in all cases. If the supervisor's action is in error, he should be corrected in private and given an opportunity to rectify his mistake without loss of prestige. The supervisor guilty of frequent errors should be replaced—preferably by dismissal rather than demotion. Few employees are able to accept demotion without ill-feeling toward the company and loss of interest in their work.

The chief engineer must avoid circumscribing the positions of the executives who form his staff command. Each of these is responsible for accomplishment of specified duties within scheduled periods, with the required degree of accuracy, in conformance with governing contracts and specifications and within limits of established budgets. Efficient discharge of these duties requires freedom of action to (1) deter-

mine detail methods best suited to accomplish the work, (2) obtain the required personnel, (3) assign this personnel to the work for which they are best suited, and (4) dismiss unsatisfactory employees—these actions being subject, in all cases, to company standard practices and methods and maintenance of lines of authority and discipline.

PERSONNEL POLICY

A prerequisite to engineering personnel control is a well-defined company policy that observes the fundamental rights of both employer and employee. This policy must be uniformly applied through the company, as exceptions and deviations applying to engineering personnel will result in discord.

Engineering cannot create the company personnel policy but can take the initiative in assisting management to establish a sound policy. Unless the company policy is healthy, it is a waste of effort to attempt engineering personnel control. Instead, engineering management should concentrate its efforts upon development of a valid company policy—followed by creation of specialized control to handle personnel matters peculiar to engineering or more vividly apparent in the engineering department.

COMPANY RULES AND REGULATIONS

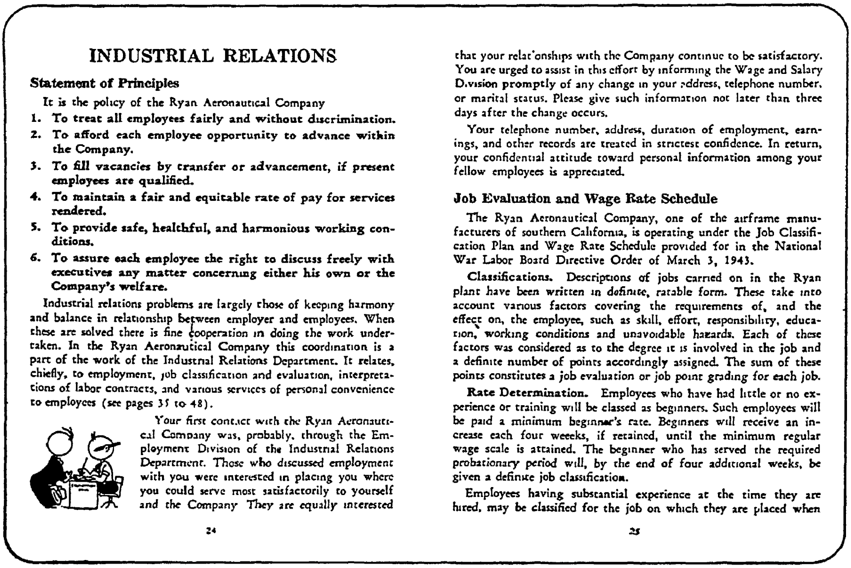
After the basic company policy is crystallized, it should be presented in an employees' manual, with copies distributed to all company personnel. The publication of this manual, stating basic rules and regulations governing conduct and duties of employer and employee, is a prerequisite to the maintenance of harmonious personnel relations. It need not be an elaborate, artistic publication. Even a brief mimeographed bulletin establishing basic company policy and rules is preferable to the confusion of a vague policy—subject to daily interpretation and *misunderstanding* by both supervisors and workers. A majority of personnel grievances stem from deficient knowledge of company policy and regulations.

EMPLOYEES' MANUAL

The preparation of an employees' manual deserves considerable thought, for it must be more than a bald statement of rules and regulations. Information must be presented in a manner that will not antagonize (for we must remember that the average human is not overly receptive to regulation) and must be sufficiently interesting to insure its being read. Its message must be free of ambiguities and impossible of

misinterpretation. The manual should present sound reasons for all prohibitions and restrictions. Employees are more likely to observe "don'ts" when it is understood that each is based upon a valid necessity.

A comprehensive employees' manual should provide information on (1) plant-protection regulations, (2) plant practices and employee conduct, (3) pay-roll regulations, (4) company personnel policy, (5) functions of the personnel department, (6) services available to employees,



INDUSTRIAL RELATIONS

Statement of Principles

It is the policy of the Ryan Aeronautical Company

1. **To treat all employees fairly and without discrimination.**
2. **To afford each employee opportunity to advance within the Company.**
3. **To fill vacancies by transfer or advancement, if present employees are qualified.**
4. **To maintain a fair and equitable rate of pay for services rendered.**
5. **To provide safe, healthful, and harmonious working conditions.**
6. **To assure each employee the right to discuss freely with executives any matter concerning either his own or the Company's welfare.**

Industrial relations problems are largely those of keeping harmony and balance in relationship between employer and employees. When these are solved there is fine cooperation in doing the work undertaken. In the Ryan Aeronautical Company this coordination is a part of the work of the Industrial Relations Department. It relates, chiefly, to employment, job classification and evaluation, interpretations of labor contracts, and various services of personal convenience to employees (see pages 35 to 48).

Your first contact with the Ryan Aeronautical Company was, probably, through the Employment Division of the Industrial Relations Department. Those who discussed employment with you were interested in placing you where you could serve most satisfactorily to yourself and the Company. They are equally interested

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that your relationships with the Company continue to be satisfactory. You are urged to assist in this effort by informing the Wage and Salary Division promptly of any change in your address, telephone number, or marital status. Please give such information not later than three days after the change occurs.

Your telephone number, address, duration of employment, earnings, and other records are treated in strictest confidence. In return, your confidential attitude toward personal information among your fellow employees is appreciated.

Job Evaluation and Wage Rate Schedule

The Ryan Aeronautical Company, one of the airframe manufacturers of southern California, is operating under the Job Classification Plan and Wage Rate Schedule provided for in the National War Labor Board Directive Order of March 3, 1943.

Classifications. Descriptions of jobs carried on in the Ryan plant have been written in definite, ratable form. These take into account various factors covering the requirements of, and the effect on, the employee, such as skill, effort, responsibility, education, working conditions and unavoidable hazards. Each of these factors was considered as to the degree it is involved in the job and a definite number of points accordingly assigned. The sum of these points constitutes a job evaluation or job point grading for each job.

Rate Determination. Employees who have had little or no experience or training will be classed as beginners. Such employees will be paid a minimum beginner's rate. Beginners will receive an increase each four weeeks, if retained, until the minimum regular wage scale is attained. The beginner who has served the required probationary period will, by the end of four additional weeks, be given a definite job classification.

Employees having substantial experience at the time they are hired, may be classified for the job on which they are placed when

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FIG. 3:1.—Specimen pages from typical employees' manual.

and (7) physical welfare, including medical services and safety regulations. The manual should be well indexed to facilitate location of information.

Although the preparation of such a manual is not a normal function of Engineering, it is desirable that engineering management be familiar with the general requirements of such a publication. Engineering is then able to offer constructive suggestions to company management during preparation or revision of the manual.

PERSONNEL RECORDS

Maintaining records of personnel transactions requires adequate forms. Identical forms should be used throughout the factory to record hiring, transfer, reclassification, and dismissal of employees. Develop-

EDUCATIONAL RECORD

	Name and Complete Address of Schools	Circle Last Grade Completed	Did You Graduate	Date of Leaving or Graduation
LAST ELEMENTARY SCHOOL		1 2 3 4 5 6 7 8		
LAST HIGH SCHOOL		9 10 11 12		

COLLEGE OR UNIVERSITY AND ADDRESS	MAJOR SUBJECTS	No. of Years Completed	Degrees Obtained	Did You Graduate	Date of Leaving or Graduation

IF YOU HAVE PURSUED ANY OTHER LINES OF STUDY SUCH AS ENGINEERING, AERONAUTICAL, VOCATIONAL OR EXTENSION COURSES, STATE FULLY WHAT SUBJECTS, WHEN, WHERE, AND FOR WHAT LENGTH OF TIME THEY WERE STUDIED.

COURSES STUDIED	NAME AND ADDRESS OF SCHOOL	PLACE	FROM	TO

Where and what was the most responsible position you ever held?

Give nature and responsibilities of that position

Use space below for anything else you may wish to tell us about your qualifications, experience, or special abilities

DO NOT WRITE IN THIS SPACE

		School	Special T.	Aero Shop	Other Shop	Hand Writing	General Appear.	Opinion of Self	Personality	Thinks	Moves	W.F.N	Nerves	Hands	Eyes	
COLLEGE	16															6
	15															5
	14															4
	13															3 VG
HIGH	12															2 G
	11															1 AA
	10															A
	9															BA
GRADE	8															P
	7															VP
	6															
	5															
	4															

Please List Hobbies, Sports, or Other Activities You Are Interested in

APPLICANT—DO NOT WRITE IN SPACE BELOW THIS LINE

Comments of Interviewer:
Job Classification Applicant Best Qualified to Do ________ Second Best ________ Third Best ________

Interviewer ________

USE INK. ANSWER ALL QUESTIONS

APPLICATION FOR EMPLOYMENT

DATE ________

Print Last Name | Print First Name | Print Middle Name (Married Woman, Give Maiden Name) | Social Security No. | Color | Race

Street and Number | City | State | Phone

Male ☐ Height ________ Age ________ Color of Eyes ________ Color of Hair ________
Female ☐ Weight ________ Nationality ________
Single ☐ Wife (or husband) work? Yes ☐ No ☐ Live with wife (or husband) ☐ Own home ☐
Married ☐ Number of dependent children ________ Live with parents ☐ Rent ☐
Widowed ☐ Number of dependent parents ________ Live with relatives ☐ Room and Board ☐
Divorced ☐ Number of other dependents ________ Live alone ☐ Room ☐

SELECTIVE SERVICE INFORMATION

Classification	Order Number	Date of Classification

Address of Selective Service Board | Number

To what extent do you read Blue Prints? ________

List Aircraft Materials you have worked with ________ Length of Shop Experience ________

Have you Tools to do the Job for which you are applying? Yes ☐; No ☐. Can you purchase necessary tools? Yes ☐; No ☐.

Type of Work You Feel Best Qualified for ________ Second Best ________ Third Best ________
Minimum Starting Rate Expected $ ________ Length of Experience ________ $ ________ Length of Experience ________ $ ________ Length of Experience ________

EMPLOYMENT RECORD—State full particulars of your occupation during at least the past ten years or more covering full disposition of your time whether employed or not. List all employers, beginning with the most recent. Give dates and periods of time as accurately as possible. Give addresses complete, including street numbers, city and state, where possible. If former employer is out of business, so state. If you were conducting your own business, give names and addresses of at least two clients who could verify your business experience. Use sufficient space to insure legibility. Print all names. First space is filled out to serve as a guide.

Employed From	Employed To	Employer's Name, Address and Kind of Business	Title of Your Job	Describe Your Duties in Detail	Salary or Wages	Reason for Leaving
Aug. 1941	*Feb. 1942*	*John Brown & Co., 12 Barr Street, Gary, Indiana Industrial Air Conditioning Equipment Manufacturing*	*Punch Press Operator*	*Set up dies in a Bliss Punch Press and operated press on strip steel to punch bolt and rivet holes.*	*10c Per Hour*	*Laid Off Lack of Work*

Fig. 3:2(a).—Employment application.

PHOTOGRAPH

Date of Birth ____ Place of Birth ____ State or Province ____ Country ____

American Citizen ____ Naturalized Citizen ____ Port of Entry ____ Name of Ship ____

Date of Entry ____ Date of First Papers ____ Date of Second Papers ____ Number ____

NAMES AND ADDRESSES OF APPLICANT'S IMMEDIATE FAMILY INCLUDING RELATIVES OF SPOUSE (Your wife or your husband)

Name of Spouse ____ Place of Birth ____

Name of Applicant's Father ____ Address ____ Place of Birth ____

Name of Applicant's Mother ____ Address ____ Place of Birth ____

Name of Spouse's Father ____ Address ____ Place of Birth ____

Name of Spouse's Mother ____ Address ____ Place of Birth ____

Other Members of Family Now Living in Foreign Countries
Name ____ Country ____
Name ____ Country ____

What Documentary Proof of U. S. Citizenship Do You Have? ____ Alien Registration Number ____

Do You Have Any Police Record Other Than Traffic Violations? ____ If Yes, Explain ____

What Physical Defects Do You Have? ____

How Long Have You Been in This State? ____ How Long in This City? ____

Please List Church, Clubs and Organizations of Which You are a Member ____

Have You any Relatives in the Employ of This Company, If so Give Their Names ____ Relationship ____

Name and Position of Any Friend Employed by This Company ____

In Case of Accident Whom Should We Notify? ____ Address ____ Phone Number ____

Have you had Military Training? ____ What Branch of Service? ____ How Long in Service? ____

Rating ____ Where? ____

Reason for Termination of Enlistment ____

Aircraft Mech. License. Yes ____ No ____ Type ____ Number ____ Expires ____

GIVE THREE REFERENCES NOT RELATIVES OR FORMER EMPLOYERS

NAME	ADDRESS	TELEPHONE	OCCUPATION

Are you, or have you ever been a member of any Communist or German Bund organization or any political party or organization which advocated or advocates the overthrow of our Constitutional Form of Government in the United States, or do you have or have you had membership in or affiliation with any group, association or organization which advocated or advocates or lent or lends support to any organization or movement advocating the overthrow of our Constitutional Form of Government in the United States?

Yes ☐ No ☐

If so, name the organization and give complete dates and details on a sheet to be attached hereto.

CERTIFICATION

I Hereby Certify that the entries on this form and the statements made by me to the officials of the Ryan Aeronautical Company are true and correct without any mental reservation whatsoever. If employment is obtained under this application, I will cheerfully comply with all orders, rules, and regulations of the employer. I agree to submit to physical examination. I also authorize my former employers and other individuals to give any information concerning me, whether or not it is on their records, and I hereby release them and their companies from any liability whatsoever. I understand that I will be subject to dismissal if anything in this application is found to be untrue.

Date ____ Witness ____ Signature of Applicant ____

MARK NUMBER OF MONTHS WORKED ON ANY OF THE FOLLOWING:

Accountant	Crane Operator	Fireman	Machinist	Lawyer	Police Officer	Time Keeper	
Assembler	Clay Modeler	Food Handler	Mechanic	Office Mach. Oper.	Printer	Truck Driver	
Bookkeeper	Doctor	Foundryman	Millwright	P.B.X. Operator	Radio	Tool & Diemaker	
Box Maker	Draftsman	Fender & Body Man	Maintenance Man	Painter	Riveter	Teacher	
Cable Splicer	Engineering	Heat-Treater	Model Maker	Photographer	Sand Blaster	Typist	
Carpenter	Estimator	Inspector	Machine Oper.	Plater	Sewing Mch. Opr.	Upholsterer	
Chemist	Electrician	Instrument Man	Nurse	Plumber	Sheet Metal Work	Watchman	
Clerk	File Clerk	Jig Builder	Newspaperman	Pattern Maker	Stenographer	Welder	

APPLICANT—DO NOT WRITE IN SPACE BELOW THIS LINE

Hired by ____ Starting Date ____ Name of Dept. Employed for ____ Shift ____ $ ____ Rate

Job Classification ____ Labor Grade ____

Remarks: ____

U. S. War Bond Payroll Deduction: ____ Amount per Pay: $ ____

Group Insurance ____ Amount ____ Beneficiary ____ Name

Other Insurance Carried ____ Amount ____ Beneficiary ____ Name

Relationship ____ Address ____ Phone No. ____

Social Security No. Checked ____ Citizenship Checked ____ Fingerprinted ____

Signature of Employee

FORM 6-B REV. 1-44 20M 3-46

RYAN AERONAUTICAL COMPANY

LINDBERGH FIELD, SAN DIEGO, CALIFORNIA, U. S. A.

FIG. 3 : 2(*b*).—Employment application (*Continued*).

ment of detail procedures and routings governing their usage is a concern of the personnel department, although engineering executives and supervisors should be familiar with the general nature of satisfactory personnel records. Occasions often arise that require engineering-management participation in conferences regarding company personnel affairs. The specimen forms shown in Figs. 3:2 through 3:11, used by all departments of a large industrial organization, represent the mechanics of adequate personnel records.

FORM NO. E-42

EMPLOYMENT NOTICE

THIS PARTIALLY FILLS EMPLOYMENT REQUEST NUMBER ____

EMPLOYEE: KEEP THIS FORM TO GAIN ENTRANCE TO PLANT AND SECURE PERMANENT BADGE AND PASS.

SOCIAL SECURITY NO ____

DATE ____ 194__

NAME ____ LAST ____ FIRST ____ MIDDLE ____ EMPLOYEE NUMBER ____

STARTING TIME ____ A. M. / P. M. STARTING DATE ____ MONTH ____ DAY ____ 19__ MALE ☐ FEMALE ☐

NAME OF DEPARTMENT EMPLOYED FOR ____ DEP'T. NUMBER ____

JOB CLASSIFICATION ____ CODE ____ LABOR GRADE ____

RATE OF PAY ____ PROBATIONARY PERIOD ____

NAME OF FOREMAN ____ INTERVIEWED BY ____

☐ FED. WITHHOLDING TAX ☐ WAR BOND GROUP INS. ☐ SELECTIVE SERVICE ☐ ☐ ☐

HIRED BY ____ I HAVE RECEIVED THE ABOVE INFORMATION ____ EMPLOYEE

PERSONNEL - RECORD
WAGE AND SALARY ADM. DIV.

RECEIVED

SIGNED ____ EMPLOYMENT MANAGER

FIG. 3:3.—Employment notice.

A comprehensive employment-application form, shown in Fig. 3:2, is the foundation of personnel records. All applicants for employment are required to prepare this prior to their first interview. The recorded information permits the determination of the applicant's suitability for available positions before an interview is granted and avoids spending time with applicants obviously unsuited for existing vacancies. The employment application becomes an authorization for hiring when approved by a department head and forwarded to the personnel department with a notation of the starting rate. If the new employee has been promised an increase at the end of a probationary period, this is also noted. Upon receipt of the approved application the personnel department initiates the employment notice shown in Fig. 3:3.

One copy of the employment notice is given the employee to insure his admittance to the company on the first day and authorizes issuance of badge and temporary identification card. Other copies are forwarded

to the personnel history file, the employee's supervisor, and the pay-roll section of the accounting department.

EMPLOYEE PROBATION NOTICE

Department .... No.. .... Date..............

Employee .... Clock No..............
Last First Middle

Hired .... Classification .... Present Rate..........

The above named employee will complete the probationary period of............days............weeks on

....

If employee is satisfactory, sign and return this form to the Wage and Salary Division. If employee is not satisfactory sign, fill in blank below and attach this form to the Termination Notice.

This employee is not satisfactory because...

Received

Signed ....
Department Head or Foreman

WAGE AND SALARY DIV.—ORIGINAL

FORM E 52 4M SETS 8-48-101

Fig. 3:4.—Employee probation notice.

The probationary review, shown in Fig. 3:4, is forwarded to the new employee's supervisor 30 days after the employee's hiring date. The supervisor can authorize a wage increase, confirm satisfactory job performance without recommendation for wage increase, or recommend termination. The recommended action is subject to approval by the supervisor's superior.

EMPLOYEE CHANGE —
CHANGE IN EMPLOYEE'S RATE, JOB CLASSIFICATION, SHIFT OR DEPARTMENT 20469

NAME________ LAST FIRST INITIAL ________RACE______ MALE ☐ FEMALE ☐ DATE________

THE STATUS OF THE ABOVE EMPLOYEE WILL CHANGE AS SHOWN BELOW.
HIRING DATE__________ REVIEW DATE__________ EFFECTIVE DATE__________

RATE CHANGE ☐ JOB CLASSIFICATION ☐ SHIFT CHANGE ☐ INTER-DEPT. TRANSFER ☐ RECORD CORRECTION ☐ SATURDAY AUTOMATIC ☐

	FROM: TO BE FILLED IN BY DEPARTMENT HEAD OR FOREMAN TRANSFERRING EMPLOYEE	TO: TO BE FILLED IN BY DEPARTMENT HEAD OR FOREMAN ACCEPTING EMPLOYEE
DEPARTMENT HEAD	DEP'T NO	DEP'T NO
EMPLOYEE'S BADGE NO		
JOB CLASSIFICATION AND CODE	CODE NO	CODE NO.
LABOR GRADE		
RATE OF PAY		
SHIFT		
DEPT HEAD OR FOREMAN'S SIGNATURE	(ORIGINATING)	(ACCEPTING)

REASON FOR THE CHANGE__________

CHANGE MADE AT REQUEST OF COMPANY ☐
REQUEST OF EMPLOYEE ☐
SIGNED________ EMPLOYEE'S SIGNATURE

WAGE AND SALARY ADMINISTRATION DIVISION
RECEIVED CHECKED____ KARDEX____ FILES____

SIGNED________ DEPT HEAD OR FOREMAN
APPROVED________ SUPERINTENDENT
ACCEPTED________ JOB EVALUATION AND WAGE ADMINISTRATION DEPT.

SEND INTACT TO WAGE AND SALARY ADMINISTRATION DIVISION RECORDS—WAGE AND SALARY ADMIN. DIV.

FORM NO. E-40 REV.

Fig. 3:5.—Employee change of status.

A change of status (see Fig. 3:5) is issued whenever an employee's rate, classification, shift, or department is changed. Copies are fur-

nished the personnel history file, the employee's supervisor, the payroll section, and the employee.

ABSENTEE REPORT
RYAN AERONAUTICAL CO.
SAN DIEGO, CALIFORNIA

TO DEPARTMENT HEAD OR FOREMEN — Date ______

Time ______

The following employee has been reported absent:

Name ______ Shift ______ Clock No. ______

REASON FOR ABSENCE

- ☐ Cold
- ☐ Personal Illness
- ☐ Transportation
- ☐ Personal Business
- ☐ Accident
- Miscellaneous (Specify) ______
- ☐ Illness in family
- ☐ Death in family

Will return ______ Taken by ______

PERSONNEL FILES — WAGE & SALARY DIVISION—INDUSTRIAL RELATIONS DEPT.

FORM E 64 5M SETS 1-44-102

FIG. 3:6.—Absentee report.

Employees unable to report for work are required to inform personnel within two hours after the start of their shift, stating the cause and anticipated duration of the absence. Personnel then prepares the

Note: Employee must report to the Industrial Relations Department upon returning from leave before starting work.

Leave of Absence

Name ______ Date ______

Department ______ Clock No. ______

I hereby request a leave of absence to begin ______ (Date),

and returning to work ______ (Date), for the following reason:

______

Leave of absence, up to thirty days, without pay and without loss of seniority, will be granted, if the request is made in writing and approved in writing for the Company by the appropriate Department head.

Extension of such leave of absence may be granted, at the discretion of the head of the Department, when written application is made to him and approved by him prior to expiration of the original leave of absence.

Upon returning from the leave of absence, the employee must report to the Industrial Relations Department before starting work.

Failure to return at, or before, expiration of leave of absence—or an extension thereof—will amount to voluntary resignation from employment.

To obtain leave of absence, an employee must put his written request on the prescribed form, in four copies: of which one copy will be retained by the Department, one will be delivered to the employee (after it has been approved), and two copies will be delivered to the Industrial Relations Department for its records.

Approved ______ Dept. Head or Foreman — Signed ______ Employee's Signature

Retain department and employee's copy and forward rest to Industrial Relations Dept.

FORM E 75 2M SETS 2-44-102

RECORDS

FIG. 3:7.—Leave of absence request.

absentee report shown in Fig. 3:6, forwarding the original to the employee's supervisor and a duplicate to the personnel history file. Per-

sonnel is notified of all absentees by Timekeeping. Those failing to report the cause of their absence are listed as absent without leave, and

NOTE: Employee must report to the Industrial Relations Dep't. upon returning from vacation before starting work.

Employee Vacation Request
RYAN AERONAUTICAL CO.
SAN DIEGO, CALIFORNIA

TO DEPARTMENT HEAD OR FOREMAN: Date

I, ______ Last Name ______ First Name ______ Middle Name ______ Badge No.

working on the ______ Shift ______ in ______ Department Name and Number

request permission to take my earned vacation time of ______ working hours with pay, at my regular rate of pay

starting ______ Day of Week ______ Date ______ and returning to work ______ Day of Week ______ Date

EMPLOYEE'S SIGNATURE ______

☐ Vacation time, as requested, APPROVED

☐ Vacation time, as requested, REJECTED

Pay in lieu of Vacation approved ☐

Pay in Lieu Approved ______

Reason for Rejection ______

To be filled in by the Wage and Salary Division

This Vacation has accrued by reason of one year's service ended ______

☐ Vacation request APPROVED by Industrial Relations Department.
☐ Vacation request REJECTED by Industrial Relations Department.

Reason for Rejection ______

Wage & Salary Adm.

Timekeeping

Department Head or Foreman

Industrial Relations Dep't.

SEND ALL COPIES INTACT TO WAGE AND SALARY DIV. INDUSTRIAL RELATIONS DEPT.

FORM E-50 5M SETS 12-44-102

FIG. 3:8.—Vacation request.

an absentee report is issued to that effect. A notice is attached to the timecard of each employee requiring appearance at Personnel to explain the cause of his absence, prior to returning to work.

Ryan Aeronautical Co.
PASS OUT
Irregular Hours

WATCHMAN: Date ......

Please Pass Mr. ...... Cl. No. ......

Who is Leaving This Department at ...... A. M. P. M. on Account of

......

...... TIMEKEEPER ...... FOREMAN

Dept. ......

FORM E-14 15M 3-44-102

FIG. 3:9.—Pass for employee leaving factory during normal work period.

Leaves of absence, up to 30 days' duration, are granted without pay or loss of seniority when requested on the form shown in Fig. 3:7. Each

request must be based upon a valid reason and be approved by the employee's department head. Copies of approved requests are distributed to the employee, his supervisor, and pay-roll and personnel depart-

FORM E-36 1-27-43 2M NO 100 Date ....

RYAN AERONAUTICAL CO.

Property Pass

NAME .... CLOCK NO. ....

PERSONAL PROPERTY: ....

☐ LOOSE TOOLS Check ☐ BOX AND TOOLS Check

Signed .... Dep't Head Dept. ....

FIG. 3:10.—Property pass.

ments. The form shown in Fig. 3:8 is used in a similar manner for vacation requests.

It is sometimes necessary for an hourly employee to leave the factory during working hours on personal or company business. A pass (see Fig. 3:9) is issued by the employee's supervisor in such cases. The

CLEARANCE REQUEST

NAME ______ DEPT. ______ CLOCK NO. ______ SHIFT ______

HIRE DATE ______ CLASSIFICATION ______ LABOR GRADE ______ MALE ______ FEMALE ______

EFFECTIVE DATE ______ TIME ______ A. M. ______ P. M. ______

NO PAYOFFS ON MONDAY

REASON FOR CLEARANCE REQUEST

TRANSFER ☐ LAYOFF ☐ QUIT ☐ DISCHARGE ☐

☐ HEALTH	☐ OTHER JOB
☐ PERSONAL AFFAIRS	☐ SUB-STANDARD PRODUCTION
☐ WAGES (EXPLAIN BELOW)	☐ INSUBORDINATION
☐ WORKING CONDITIONS	☐ VIOLATION OF COMPANY RULES
☐ HOUSING CONDITIONS	☐ NON-ATTENDANT
☐ TRANSPORTATION	☐ LACK OF WORK
☐ LEAVING CITY	☐ UNDER UTIL. OF SKILL
☐ PHYSICAL HANDICAP	☐

GRADE EMPLOYEE WITH CHECK ☒	EXCELLENT	GOOD	FAIR	POOR
CONDUCT				
ABILITY				
PRODUCTION				
ATTENDANCE				

CHANGE AT REQUEST OF: ☐ EMPLOYEE ☐ COMPANY

SHOULD EMPLOYEE BE CONSIDERED

	YES	NO
FOR REHIRE IN DEP'T.?	☐	☐
IN ANY OTHER DEP'T?	☐	☐

NOTICE GIVEN

DATE ______

TIME ______ A. M. P. M.

FORWARDING ADDRESS

RECEIVED BY:

PAYOFF WAGE & SALARY ACCOUNTING

SUPERVISOR'S ACTION ______

INTERVIEWER'S ACTION ______

SIGNED ______ (SUPERVISOR) (DEPT. HEAD) SIGNED ______ (INTERVIEWER)

(FOR ADDITIONAL SPACES, USE REVERSE SIDE OF THIS COPY)

PERSONNEL RECORDS SEND INTACT TO THE FACTORY RELATIONS SECTION, INDUSTRIAL RELATIONS DIVISION. FORM E-38 REV.

FIG. 3:11.—Clearance request.

original authorizes company guards to permit the employee to leave; the duplicate is placed in the personnel history file. The property pass shown in Fig. 3:10, when signed by a department head, authorizes com-

pany guards to permit the employee to leave the plant with the stipulated property.

All employees scheduled for termination are interviewed to determine the possibility of transfer to another department as an alternative to dismissal. When an employee is dismissed for gross misconduct, this possibility does not exist, but transfers are often arranged for employees dismissed as the result of changing departmental requirements. The clearance request shown in Fig. 3:11 is initiated whenever an employee is scheduled for termination and upon being forwarded to the personnel department inaugurates the pretermination interview. Following the interview the clearance request is returned to the employee's department head for approval, followed by distribution of copies to department head, pretermination interviewer, personnel history file, pay-roll section of accounting, and personnel department pay-off desk. Pay roll issues the employee's final check upon receipt of their copy of a termination clearance notice and forwards the check to the pay-off desk for delivery to the employee upon completion of termination procedure.

ENGINEERING PERSONNEL CONTROL

The general requirements for engineering personnel control are similar to those of other departments. Personnel control establishes simple, practical methods of handling personnel procurement, complaints, and terminations; maintaining personnel assignment and history records; and administrating wages and salary. A large engineering department also needs a method of training new employees in company procedures. Occasionally education programs are required for both workers and supervisors.

Company personnel departments are well qualified to handle the general personnel work of recording employment applications, investigating citizenship and references, recording absentees, and maintaining employee histories. Rarely are they sufficiently familiar with engineering problems to handle all detailed personnel affairs. Thus, it is desirable to establish supplementary personnel controls within Engineering.

Detailed personnel affairs comprise (1) interviews, (2) classifications, (3) employee records, (4) complaints, (5) training supervisors in handling men, (6) wage and salary reviews, (7) transfers, (8) terminations, (9) overtime, and (10) shop passes. Although some of these are not peculiar to Engineering, they are frequently more acute there than in other departments.

ENGINEERING PERSONNEL MANAGER

When the engineering force is small, the departmental personnel affairs are usually handled by the administrative engineer or the chief draftsman. As the department grows, the personnel work keeps pace, and a point is reached where the burden justifies the establishment of an engineering personnel manager. The duties of this position involve handling all personnel affairs for the engineering department, and considerable care is necessary in selecting the person for this position. To be truly effective the engineering personnel manager must be able to relieve the chief engineer and his staff of personnel duties by acting for the chief engineer in the majority of personnel affairs. The engineering personnel manager must be well versed in human relations and be able to obtain the confidence of employees to the extent that they will feel that the personnel manager's decisions are identical with those of the chief engineer.

The engineering personnel manager must truly become an *alter ego* of the chief engineer, delegated to act in all matters relating to personnel. This can be accomplished if all employee complaints are referred to the personnel manager and no action taken in human-relations problems without first consulting the personnel manager. When employees realize that it is futile to attempt to circumvent the engineering personnel manager by direct appeal to engineering executives, the personnel manager will become of real value in relieving these executives of detailed personnel affairs.

One of the most unpleasant duties of the engineering personnel manager is sitting in judgment upon an employee accused of misconduct. It is vitally important to maintain a reputation for fairness in such cases. The Roman code of justice does not apply in this country, and the employee must always be considered innocent until proved guilty. Every effort should be made to investigate all circumstances fully, and little faith placed in hearsay evidence. An employee should never be accused, tried, convicted, and sentenced without ample opportunity to present a defense and confront his accusers. To do otherwise is a certain method of destroying employee morale.

EMPLOYMENT INTERVIEWS

Preliminary interview of all prospective engineering employees is a function of the engineering personnel manager. This screening eliminates the obviously unfit and directs promising candidates to the proper executive or supervisor for final interview.

Salary is an important consideration during final interviews of prospective employees. Each executive authorized to hire personnel must be familiar with company wage and salary schedules and should avoid starting new employees at the top rate for a particular job classification. Unless this caution is observed, it is difficult to reward good workmanship with wage increases except by reclassification, which is sometimes neither possible nor desirable. This may make necessary a starting rate lower than that previously earned by the prospective employee. The prospect will usually accept the lower starting rate if the position is shown to offer good opportunity for advancement or considerable security.

Care must be used to avoid expressed or implied promises of future wage increases. Unless it is definitely known that a specified increase can be granted at the end of a stipulated period of satisfactory job performance, it is unwise to make commitments. Ambiguous promises lead only to employee discontent in later weeks. When a definite increase is promised at the end of a probationary period, it should be granted without the employee having to remind his supervisor. A notation of the promised wage increase should appear on the approved employment application. This permits the engineering personnel manager to remind the supervisor by initiating a special wage review shortly before the end of the probationary period.

PERSONNEL HISTORY RECORDS

Complete histories of each employee are essential in engineering because of the highly specialized and varied work involved. Frequent personnel transfers from one section to another to meet schedules also require immediate access to employee records. The history file for each engineering employee, normally maintained by the company personnel department, should be retained by the engineering personnel manager. This file begins with the approved employment application authorizing hiring the employee and receives copies of subsequent employment notice, change of status forms, absentee reports, wage and salary reviews, and other personnel records. It is advisable to provide also a summarized employee history record, in addition to this master file, for ready reference to pertinent facts regarding each employee.

A satisfactory engineering employee record is shown in Fig. 3:12. This is an 8½ by 11-in. card having on one side a concise record of personal facts, experience, wage increases, and attendance. A date strip along the upper margin is flagged with colored signals to indicate draft-deferment expiration, vacation, and next wage-review times. The

Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.

ENGINEERING EMPLOYEE RECORD

NAME

CLOCK No. DIV.

Address Phone Age
New Address Phone Draft Class Issued Until
New Address Phone Reclassified Issued Until
New Address Phone Reclassified Issued Until
New Address Phone Reclassified Issued Until
Marital Status No and Age of Children Wife Employed

Position Date Salary $
Advanced Date Salary
Advanced Date Salary
Advanced Date Salary
Advanced Date Salary
Advanced Date Salary
Advanced Date Salary
Advanced Date Salary

TRAINING
Mathematics Yrs High School Yrs College
Mech. Draw. Yrs. High School Yrs. College
SPECIAL COURSES:
(School) (Subject) (Yrs)

PRACTICAL PAST EXPERIENCE:
(1)
(2)
(3)
(4)
(5)
(6)
(7)

GROUPS IN WHICH SUBJECT HAS WORKED:
Fuselage Armament
Emp. and Wing Checking
Equipment Stress
Fl. Contr. Prod. Il.
Ldg. G. and Hy. Weights
Pow. Plant Aerodyn.
Prel. Des.

TARDINESS AND ABSENT

	TARDY		ABSENT		TARDY		ABSENT			TARDY		ABSENT		TARDY		ABSENT	
Jan.									July								
Feb									Aug.								
Mar.									Sept.								
Apr.									Oct.								
May									Nov								
June									Dec.								
	No. Times	Hours	A. W. L.	A. W. O. L.	No. Times	Hours	A. W. L.	A. W. O. L.		No. Times	Hours	A. W. L.	A. W. O. L.	No. Times	Hours	A. W. L.	A. W. O. L.

TOTALS

No. Times	Hours	A. W. L.	A. W. O. L.	No. Times	Hours	A. W. L.	A. W. O. L.
TARDY		ABSENT		TARDY		ABSENT	

(a)

NAME

GROUPS IN THIS ORGANIZATION SUBJECT HAS WORKED IN:
Fuselage Armament
Emp. and Wing Checking
Equipment Stress
Flt. Cont. Prod. Il.
Ldg. G. and Hy. Weights
Pow. Plant Aerodyn.
Prel. Des.

LAST RATE REVIEW
Recommendation
Recommendation
Recommendation
Recommendation
Recommendation
(Date)

EMPLOYEE RATING RECORD

Jan.			Jan.			Jan.			Jan.			Jan.			Jan.		
Feb.			Feb.			Feb.			Feb.			Feb.			Feb.		
Mar.			Mar.			Mar.			Mar.			Mar.			Mar.		
Apr.			Apr.			Apr.			Apr.			Apr.			Apr.		
May			May			May			May			May			May		
June			June			June			June			June			June		
July			July			July			July			July			July		
Aug.			Aug.			Aug.			Aug.			Aug.			Aug.		
Sept.			Sept.			Sept.			Sept.			Sept.			Sept.		
Oct.			Oct.			Oct.			Oct.			Oct.			Oct.		
Nov.			Nov.			Nov.			Nov.			Nov.			Nov.		
Dec.			Dec.			Dec.			Dec.			Dec.			Dec.		
Average			Average			Average			Average			Average			Average		

TAB LEGEND
Red—Draft Expiration
Yellow—Vacation
Blue—Rate Review

Current Date

NAME

VACATION GRANTED Paid In Lieu Thereof
From To $
From To $

(b)

FIG. 3:12.—Engineering employee record.

other side of this record lists the employee's experience within engineering, vacations, wage-adjustment recommendations, and job-performance ratings. The space for the last item provides both for the ratings recommended by the employee's supervisor and for corrected ratings approved by the engineering personnel manager.

WAGE AND SALARY REVIEWS

Each engineering employee should be periodically reviewed on the basis of job performance to ascertain if an increase in wage or salary is merited. The practice of hit-or-miss increases cannot be tolerated, and it is necessary to provide a simple, effective method of reviewing each employee at specified intervals. Frequency of review is governed by company policy, union contracts, or a combination of both but in all cases must be definite and understood by all employees. A 16-week period is often used for hourly employees and semiannual reviews for salaried personnel. All job-performance ratings should be made by the employee's immediate supervisor, subject to approval of his superior and the engineering personnel manager.

The employee performance rating form shown in Fig. 3:13 is for nonsupervisory hourly personnel and provides 12 variations in each of 10 basic factors. A cross is inserted in the numbered square opposite the condition that best describes the employee's performance. Each column is totaled, and a grand total entered in the lower right corner of the card. This is the employee performance rating and determines the advisability of an increase in pay. An employee failing to receive a rating of 95 or better rarely merits an increase. A job-performance schedule for nonsupervisory salaried employees is shown in Fig. 3:14. A rating of less than 79 rarely justifies a salary increase. A similar performance-rating method is used for supervisory personnel (see Fig. 3:15) except for rearrangement of data on the form. Emphasis is placed upon leadership, cost consciousness, and employee relations. A score of 375 or better is usually necessary to merit a salary increase.

SEE INSTRUCTIONS ON REVERSE SIDE

DATE__________SHIFT__________

NAME____________________

CLOCK NO.____________________

CLASSIFICATION	RATE	GRADE

SIGNED____________________

APPROVED____________________
Dept. Head or Foreman

		EXCELLENT	AVERAGE	BELOW AVERAGE	DEFICIENT
1	INTEREST IN WORK	12 Puts forth extreme effort to improve in all ways. 11 Always improving knowledge. Trying to increase output 10 Shows interest in work and strives to improve	9 More than usual interest in work. Tries to improve. 8 Usually interested in work and does it well. 7 Likes work somewhat. Does it fair as a rule	6 Tries to improve when told. Content "as is." 5 Shows lack of interest in work. 4 Makes little effort to do better	3 Occasionally careless. Mind wanders. 2 Dislikes work. Makes no effort to improve. 1 Resents offers of advice or assistance.
2	APPLICATION	12 Constantly very busy. Never leaves work 11 Always busy. Seldom leaves work 10 Most always busy. Occasionally away from work.	9 Usually busy. May require occasional prompting 8 Normally busy. Occasional prompting required 7 Fairly busy. Frequent prompting required	6 Casually busy. Requires considerable prompting. 5 Does better only when told. Much prompting required 4 Excessive prompting. Leaves work for long periods	3 Needs prompting continually. Away from work much. 2 Wastes time. Stares into space. Indifferent. 1 Leaves work too much. Pays no attention to prompting.
3	ABILITY TO LEARN	12 Brilliant. Learns very quickly 11 Is able to master practically all situations in short time 10 Bright. Learns quickly. Retains knowledge.	9 Masters most situations very soon. 8 Learns fairly quick. Remembers instructions. 7 Average intelligence. Able to advance somewhat.	6 Learns somewhat slowly, but retains most knowledge. 5 Learns slowly. Occasionally forgets instructions. 4 Learns slowly. Forgets	3 Seems to comprehend instructions with difficulty. 2 Does not seem to understand instructions. 1 Absorbs practically no knowledge. Dull.
4	ACCURACY	12 Most accurate. Does work to very exacting tolerances. 11 Very few errors. Does work to fairly exacting tolerances. 10 Very accurate. Does work to very close tolerances.	9 Few errors. 8 Satisfactory. Usually turns out acceptable work. 7 Occasional rework necessary	6 Fair. Most work acceptable. Some rework. 5 Occasional rejections. 4 Due to not using sufficient care, makes errors.	3 Much spoiled work 2 Work unsatisfactory. Many errors. 1 Much loss due to rejections and rework.
5	SPEED	12 Very fast. Consistently a rapid worker 11 Always above average in daily production. 10 Fast. Usually turns out more than average day's work.	9 Production always high. Fairly fast worker. 8 Occasionally somewhat ahead in work. Reasonably fast. 7 Keeps up with production requirements. Average.	6 Scarcely keeps up with requirements 5 Frequently behind in work 4 Slow. Seems to be unable to keep up with work.	3 Usually behind. 2 Very slow. Makes no progress. 1 Always far behind schedule.
6	RELIABILITY	12 Most dependable. Always can be counted on. 11 Fulfills all requirements and usually more 10 Very dependable. Can safely be counted on.	9 Fulfills requirements satisfactorily. 8 Dependable. Needs very little watching 7 Seldom "slips up" on procedure	6 Fair, but bears watching. May "slip up" on procedure. 5 Requires much supervision. 4 Cannot be depended upon to keep busy.	3 Apt to produce inaccurate work. 2 Very undependable. Almost certain to waste time. 1 Sure to spoil some work if not closely watched.
7	INITIATIVE	12 Extremely original. Plans work to smallest detail. 11 Original and resourceful. Plans work well 10 Fairly original. Seldom requires instructing	9 Takes hold of work very well. Requires little aid 8 Takes hold of work well. Seeks advice when in doubt. 7 Takes hold of work fair, but somewhat overcautious	6 Takes hold of work fair, but neglects caution. 5 Strong tendency to risk making errors. 4 Must be prompted often. Lets things slide.	3 Requires much supervision 2 Requires continual prompting to attend to business. 1 Too much supervision required.
8	JUDGMENT	12 Unusual sense of proportion. 11 Seldom—if ever misinterprets orders or instructions. 10 Very good judgment. Usually does the right thing	9 Usually interprets orders and instructions correctly 8 Usually able to determine good from bad methods 7 Corrects faulty procedure during process, as a rule.	6 May accept methods of procedure without question. 5 Frequent loss due to errors in judgment. 4 Apt to make wrong decisions regarding work.	3 Often attempts to "get by" with faulty work. 2 Unable to judge good from poor work 1 Takes wrong attitude when corrected
9	CONDUCT	12 Behavior perfect. Trys to get along with everyone 11 Excellent cooperation with superiors. 10 Good behavior. Considerate of others	9 Cooperates cheerfully with superiors 8 Observes company rules. Gets along with others. 7 Obeys orders without comment. Usually neutral	6 Obeys orders. Fair on rules. Cooperates reluctantly 5 Plays occasional pranks. May occasionally argue. 4 Frequently lax in observance of Company rules.	3 Plays around. Interferes with work of others. 2 Disregards rules. Loafs with others. Quarrelsome. 1 Argues with superiors. Antagonistic.
10	ATTENDANCE	12 No time off. Never late. Always on the job 11 Never requests pass out. Never late. Seldom off 10 Little time off. Seldom late. Nearly always on the job	9 Rarely requests pass out. Only occasionally late 8 Seldom out or late for work. Occasional pass out. 7 Frequent pass out.	6 Some time off and occasionally late 5 Frequent pass outs. Frequently off or late. 4 Much time off. Often late to work.	3 Gives too much attention to outside business. 2 Practically never on time. Too much time off 1 Seldom on the job.
	Totals	12 | 11 | 10	Totals 9 | 8 | 7	Totals 6 | 5 | 4	Totals 3 | 2 | 1 — TOTAL

FIG. 3:13(*a*).—Job-performance rating form for nonsupervisory hourly employees.

This card must be completed, signed, approved and returned to the Job Evaluation Department within 48 hours.

INSTRUCTIONS

Each employee must be carefully appraised and graded. For example, in the column at the left the first factor is "Interest in Work." To the right we find twelve sentences. Choose the one which best fits the employee and insert a cross (X) in the numbered square. Follow the same procedure for the other nine factors. Total each column, then insert the grand total in the lower right hand corner of card.

If the card is shown as a beginner indicate what the first classification should be by inserting it under beginner. If a reclassification is desired the same procedure is followed.

If a wage adjustment is not recommended, explain______________________________

Signed______________________

FORM E37 8M 3-45-102

Fig. 3:13(*b*).—Reverse side of job-performance rating form for nonsupervisory hourly employees.

NONSUPERVISORY PERSONNEL REVIEW Date ________

Department ________________

Employee ________________ Clock No. ________ Position ________________

In conducting this review, be exact and impartial. Remember that you are making this review to let the employee know how he is regarded, and to serve as a basis for constructive suggestions. It should represent the views of the two persons immediately over him in line of authority.

On the rating form below, judge this employee on the basis of the work now being done. For each factor, place an "X" on the line, selecting the degree you feel best fits the employee under consideration:

	Poor			Fair			Good			Excel.
	1	2	3	4	5	6	7	8	9	10
Job Knowledge										
Dependability										
Ability to follow instructions										
Results Obtained										
Initiative										
Accuracy										
Efficiency										
Interest in work										
Cooperation with others										
Supervisory Ability										

REMARKS: ________________

Has this rating been discussed with the employee? ________ If so, what was his reaction? ________

Rated by ________________ Checked by ________________ Date ________

Return to: *Wage & Salary Administration Division, Industrial Relations Department.*

E-106

FIG. 3:14.—Job-performance rating form for nonsupervisory salaried employees.

SUPERVISORY DEVELOPMENT REVIEW

Date ____________

Dept. ____________

Employee ____________ Clock No. ______ Position ____________

In conducting this review, be exact and impartial. Remember that you are making this review to let the employee know how he is regarded, and to serve as a basis for constructive suggestions. It should represent the views of the two persons immediately over him in line of authority. On the rating form below, judge this employee on the basis of work now being done.

		Poor 1	2	3	Fair 4	5	6	Good 7	8	9	Excel. 10	
LEADERSHIP and EMPLOYEE RELATIONS	Disposition											
	Tact and diplomacy											
	Respect for subordinates											
	Regard for Employee Problems											
	Disciplinary Control											
	Handling of grievances											
	Personal appearance											
	Social conduct (deportment)											
	Utilization of employee's abilities											
	Delegation of authority											
	Gives credit where due											
	Development of subordinates											
	Promotion of goodwill											
	Organizational ability											
DEPENDABILITY and JUDGMENT	Interest in work											
	Ability to get all facts											
	Ability to weigh and decide											
	Judgment											
	Acceptance of criticism											
	Ability to follow instructions											
	Ability to assume responsibility											
	Follow-through											
INITIATIVE and RESOURCEFULNESS	Development of new ideas											
	Energy and aggressiveness											
	Ability to make decisions											
	Ability to get results											
	Application of new techniques											
	Ability to think for self											
KNOWLEDGE	Job Knowledge											
	Knowledge of Company policies											
	Advancement of knowledge of job											
	Attitude toward knowledge of others											
	Ability to inform others accurately											
	Solution of job problems											
COORDINATION and COOPERATION	Attitude displayed with others											
	Ability to maintain harmony											
	Acceptance of decisions											
	Appreciation of all problems involved											
	Coordination with other groups											
	Cooperation with others											
PLANNING COSTS STANDARDS	Housekeeping											
	Ability to meet schedules											
	Care of equipment											
	Planning											
	Accuracy											
	Ability to reduce costs											
	General workmanship standards											
	Enforcement of safety regulations											

REMARKS: ____________

Rated by ____________ Checked by ____________ Date ____________

Return to: *Wage & Salary Administration Division, Industrial Relations Department.*

E-105

FIG. 3:15.—Job-performance rating form for supervisors.

OVERTIME

Overtime is an evil that should be avoided wherever possible, and under no circumstances should it become customary. It is a proved fact that when overtime exceeds a few consecutive days, the continued mental fatigue causes employee slowdown to a point where the work accomplished during a normal work day plus overtime is not greater than was originally accomplished without overtime. Quality of work rapidly deteriorates when employees are subjected to a continued overtime schedule. When overtime is readily obtained, a tendency may develop for supervisors to be overoptimistic regarding completion dates, on the premise that overdue jobs can always be rushed through to completion on overtime.

TO: CHIEF DRAFTSMAN   INTERSTATE AIRCRAFT AND ENGINEERING CORP. WILSHIRE DIVISION   DATE OF OVERTIME________

FROM:________GROUP   **OVERTIME REQUEST**

MUST BE TURNED IN BY 3:00 P.M. FOR WEEK DAYS. BY 11:00 A.M. SATURDAY FOR SUNDAY.

CLOCK NO.	NAME	HOURS		PROJECT	CLOCK NO.	NAME	HOURS		PROJECT
		FROM	TO				FROM	TO	

GROUP LEADER________   APPROVED________

FORM 199-W

FIG. 3:16.—Overtime request.

However, there are occasions when overtime is necessary, and a satisfactory control must be established to care for these cases. The authority to approve or reject all overtime requests should be delegated to either the administrative engineer or the chief draftsman, depending upon the organizational structure of the department. All supervisors requiring overtime should make written request before the close of the workday (see Fig. 3:16), listing their personnel involved and the reason for the overtime. Upon approval of the request a special overtime pass (see Fig. 3:17) is issued to each employee authorized to work overtime. This pass permits the employee to gain admittance to the department

after regular working hours and is turned in with the employee's timecard on the following morning. The pass is the timekeeper's authority to accept the overtime shown on the timecard.

OVERTIME AUTHORIZATION
El Segundo Division
FOR ALL OVERTIME BEYOND REGULAR HOURS

EMPLOYEE:.. CLOCK NO. ....
is authorized to work overtime as follows:

DATE	FROM	TO	HOURS

Reason for Overtime..

....
Supervisor

Overtime authorization must be secured BEFORE overtime worked. Place this authorization in rack with your time card the same day overtime is worked.
FORM 71 E

Fig. 3:17.—Overtime pass.

There is a genuine need for using a formal method of requesting overtime and establishing deadlines for submitting these for executive approval. Unless this is done, it is difficult to keep supervisors alert to the necessity of planning sufficiently far in advance to avoid the frequent occurrence of sudden emergency work.

SHOP PASSES

Another vexing problem is the control of nonsupervisory employees who must visit factory departments in connection with engineering

VULTEE AIRCRAFT INC
VULTEE FIELD DIVISION

SHOP PASS BUTTON NO.____________

GOOD FOR ENGINEERING BUTTON WHICH MUST BE DISPLAYED IN FULL SIGHT WHEN ENTERING ANY DEPARTMENT IN THE SHOP.

DRAFTSMAN____________________ DATE____________

GROUP LEADER'S O.K ____________________ TIME ISSUED____________
FORM NO V F D 124-6

Fig. 3:18.—Shop pass request.

work. The prerogative of freely visiting other departments cannot be extended, for there are always a few employees who are certain to take advantage of the privilege.

A simple solution is the use of a shop-pass badge that must be worn by nonsupervisory engineering employees whenever in other departments. This is effective when company policy establishes that shop foremen shall refuse to allow the presence in their department of a nonsupervisor engineering employee who is not wearing a shop-pass badge. A shop-pass request form (see Fig. 3:18) must be signed by the employee's supervisor before presentation to the chief draftsman's office to obtain a shop pass.

When a guard is stationed at the entrance to Engineering, it can be made his responsibility to issue these badges upon presentation of a properly authorized request. The badges are loaned only for a short period and must be returned before the close of the day on which they were issued.

CHAPTER 4

COST CONTROL

Methods for collecting and allocating costs are a basic necessity for the engineering department, since intelligent planning is impossible without accurate knowledge of costs, both in man-hours and money. A thorough cost-control system goes beyond the strictly timekeeping and accounting phases of collecting and allocating costs. It also encompasses cost reduction through application of sound industrial engineering and production-design principles.

Cost control is closely allied to engineering planning, and both are prerequisites for efficient operation of the engineering department. When these activities are functioning, work will be completed within allowed budgets on scheduled completion dates and will be properly coordinated to insure fulfillment of all requirements.

BUDGETARY CONTROL

The first step in cost control is establishment of an over-all budget for the engineering department, followed by individual budgets for each operating unit. These budgets must have flexibility for possible revision to accommodate changes in engineering work in progress.

Each unit of engineering must operate within its current budget and be governed by periodic budget reports issued by the cost-control activity. A time-charge system must be established to give daily cost accumulation by charging every engineering hour against a designated account. These acounts not only must provide for charging time against each project within engineering, but must also provide sufficient detail breakdown to show exactly how costs are distributed within each project. This permits compilation of cost records that indicate why budgets are exceeded or decreased.

No engineering work must be accomplished until an account is assigned to cover the job. Each employee furnishes the cost-control group a daily report showing the distribution of his day's work, with the proper number of hours allocated to each account. These daily costs reports are then summarized by Cost Control to show cost allocations and budget expenditures.

When tabulating machines are available, it is practicable to use the employee's daily timecard for recording costs. The engineering cost-control group can then be furnished a daily record of cost distribution by the tabulating department.

A time-charge account system adequately providing for accumulation and segregation of engineering costs is detailed in Appendix I. The method described is based upon work orders issued by the engineering planning group and can be independent of general company timekeeping and accounting practices. This makes possible establishment of accurate engineering costs in the absence of comprehensive cost regulation throughout the company.

MASTER AUTHORIZATION PROCEDURE

The most desirable condition exists when a unified cost-control system operates throughout the company. A system of authorizing all company expenditures is established under the control of a master planning activity. The master-authorization procedure provides a method of accomplishing this end. An authorization is issued to establish a budget for each contract. Other authorizations approve capital expenditures, budgets for service departments and development work, and appropriations for speculative manufacture. Neither time nor money can be expended without master-authorization approval.

Upon issuance of a master authorization, the collecting and segregating of detail costs is accomplished by issuance of departmental work orders. Each work order is referred to the relevant master authorization and authorizes accomplishment of certain portions of the approved expenditure.

The issuance of work orders is accomplished by the engineering and manufacturing-planning groups. The former authorizes engineering expenditures; the latter issues orders relating to manufacturing departments. Overhead departments, such as purchasing and sales, usually charge time against the master authorization. Work orders can be issued for strictly overhead departments when management desires detailed accounting of their expenditures.

The issuance of each master authorization affects both company and departmental budgets. Corresponding revisions of the budgets affected should be issued by Master Planning simultaneously with each new authorization. Master Planning also prepares weekly budgetary reports, showing the progress of each department in maintaining budgets. All budget excesses should be investigated to ascertain the cause and apply corrective measures. Work completed below the budget alloca-

CONSOLIDATED AIRCRAFT CORPORATION
SAN DIEGO, CALIFORNIA

REQUEST FOR MASTER AUTHORIZATION

MASTER AUTHORIZATION SUPERVISOR: DATE ____________

Please arrange for authorization of the following: DESCRIPTION

EXPLAIN IN DETAIL NECESSITY FOR THIS REQUEST

APPROXIMATE COST $____________ (TO BE INSERTED BY REQUESTOR)

To be used by. DEPARTMENT NAME	DEPT NO	BLDG NO	PLANT NO

REQUESTED BY	DATE WANTED	APPROVED BY

APPROVALS	THIS SPACE FOR USE OF M A OFFICE
....	REQUEST NO R________ SERIAL NO ________
....	RECEIVED BY________________ 194__
....	COST ESTIMATE ________ $________
....	ESTIMATED BY________________
....	M A NO ________ ISSUED________ 194__
....	CHARGE TO________________

FORM 707A

• Fill out in triplicate. Send white original and green copy to M. A. Supervisor. Retain yellow copy.

FIG. 4:1.—Request for issuance of master authorization. Forwarded by department head requesting establishment of budget and issuance of authorization for a specific expenditure.

CUSTOMER'S ORDER NO.	CONSOLIDATED VULTEE AIRCRAFT CORPORATION VULTEE FIELD DIVISION **MASTER AUTHORIZATION**	M. A. NUMBER ORIGINAL | SUPPLEMENT
DATE 19	MODEL DATE 19	PAGE 1 OF

SUB ORD NO	ITEM NO	QUANTITY	DESCRIPTION	PART NO.	UNIT PRICE	TOTALS

SPECIAL INSTRUCTIONS.

CHARGE TO—

SHIP TO

ADDRESS

SHIP VIA

SCHEDULE	BEGIN DELIVERY	INSP. BY
	COMPLETE DELIVERY	INSP. AT

( ) ACCOUNTING	( ) PRODUCT ENGINEERING	( ) PURCHASING	REQUESTED BY
( ) ARMY OFFICE	( ) PRODUCTION CONTROL	( ) FILE	
( ) IND. ENGINEERING	( ) RECEIVING CLERICAL	( )	AUTHORITY
( ) INSPECTION	( ) FACTORY SUPT.	( )	
( ) MASTER SCHEDULING	( ) TRAFFIC	( )	
( ) MATERIAL CONTROL	( ) TOOLING	( )	
( ) PLANT ENGINEERING	( ) WORKS MANAGER	( )	

108-10-5

FIG. 4:2.—Master authorization issued to approve capital expenditures, budgets for service departments and development work, and appropriations for speculative manufacture.

tion should also be investigated. Either the estimate was in error or improved methods have been developed. These can often be applied to reduce costs in other departments.

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
VULTEE FIELD DIVISION
VULTEE FIELD, CALIFORNIA

MASTER AUTHORIZATION CLOSURE

DATE________________19___

MASTER AUTH. NO.________ SUPPL. NO.________ SUB ORD. NO.________ IS THIS DAY

( ) COMPLETED AND NO MORE TIME OR MATERIAL IS TO BE CHARGED TO THIS ACCOUNT.

( ) CLOSED AND NO MORE TIME OR MATERIAL IS TO BE CHARGED TO THIS ACCOUNT.

( ) TEMPORARILY CLOSED UNTIL FURTHER NOTICE.

( ) CANCELLED ( ) REOPENED ---- UNDER CONDITIONS NOTED BELOW.

EXPECT TO REOPEN________________19___
ISSUED:
REMARKS:

COPIES TO:

( ) ACCOUNTING	( ) PRODUCT ENGINEERING	( ) PURCHASING	
( ) ARMY OFFICE	( ) PRODUCTION CONTROL	( ) FILE	APPROVED BY:
( ) IND ENGINEERING	( ) RECEIVING CLERICAL	( ) AAF AUDIT	
( ) INSPECTION	( ) FACTORY SUPT	( ) AAF CONT OFF	
( ) MASTER SCHEDULING	( ) TRAFFIC	( )	
( ) MATERIAL CONTROL	( ) TOOLING	( )	____________
( ) PLANT ENGINEERING	( ) WORKS MANAGER	( )	

102-21F-1

FIG. 4:3.—Master authorization closure notice issued when authorized expenditure is completed or upon withdrawal of management approval.

ESTIMATING ENGINEERING COSTS

The secret of accurately estimating the expense of engineering projects lies in compiling accurate cost records over an extended period. New

projects can then be studied in the light of their relationship to previous projects. Allowances can be made for variations in complexity of the work involved to arrive at an intelligent estimate of the time required to complete the new project.

The basis for estimating may be the quantity of drawings involved. This method is usable for small articles, where the quantity of drawings can be fairly accurately estimated. With the application of data previously compiled regarding the man-hours required to complete average layout, assembly, and detail drawings for that product, a reasonable estimate of man-hours can be made.

In the case of large, complex articles such as an airplane, it is more logical to gather data on the engineering cost per pound for various types of the product. Cost data can then be based upon the estimated weight empty of a new design.

In any case, a record of engineering costs must be compiled over the course of several projects before accurate cost estimation is possible. The only alternative is to obtain information on the engineering costs of other companies manufacturing a similar product and to use that as a basis. It is dangerous to accept the data of another company too literally, for the conditions that govern engineering costs, such as caliber of personnel and efficiency of management, are almost certain to be different. In any event, an engineering cost-control group can be considered as primarily a statistical function until sufficient data is accumulated on actual costs to permit accurate forecasts.

Costs have been referred to in terms of man-hours, which is the most logical method since the man-hours required to accomplish specified work tend to remain more stable than money value. On the other hand, it is necessary to establish engineering budgets and other cost data in terms of money. This is done easily after basic man-hour costs are established by simply multiplying man-hours by the unit engineering cost for the particular work.

Unit engineering costs vary greatly with the nature of the work and the size of the department. Overhead increases inevitably with departmental growth, owing to the increased requirements for full-time supervising, checking, and technical and clerical personnel. Each cost-control group should ascertain the costs within their engineering department for each of the different types of basic work involved rather than attempt to take an average value and apply this to all estimates.

A weekly summary of cost distribution can be used to acquaint all concerned with the cost distribution within each project. The summary shown in Fig. 4:4 was prepared near the conclusion of the development program for a large single-engine dive-bomber airplane and shows

Copies to: Controller's Office (2)
Chief Engineer
Chief Devl. Engr. (5)
Administrative Engr. (3)
Chief Draftsman (2)
Issued by

Jones Aircraft, Inc. - Engineering & Development Dept.

ENGINEERING HOURS REPORT - MODEL 82

Week Ending 5-1-42   Report No. C500

Description of Work	Detail Ref. #	Hours Spent This Week	Hours Spent To Date	Estimated Final Hours	Budget	Est. Hours Remaining	Budget Hours Remaining	Over Under Budget
Layouts			60,503.6	60,503.6	60,570.0		+ 66.4	+66.4
Assemblies & Details			85,806.4	85,806.4	84,775.0		−1,031.4	−1,031.4
TOTAL LAYOUT & DETAILS			146,310.0	146,310.0	145,345.0		−965.0	−965.0
Supervision			8,860.6	8,860.6	8,700.0		−160.6	−160.6
Preliminary Design			11,255.9	11,255.9	11,260.0		+ 4.1	+ 4.1
Checking			36,622.9	36,622.9	35,185.0		−1,437.9	−1,437.9
Stress			38,279.5	38,279.5	36,655.0		−1,624.5	−1,624.5
Weights			12,803.4	12,803.4	12,606.0		−197.4	−197.4
Lofting			11,738.1	11,738.1	11,720.0		−18.1	−18.1
Template			2,907.3	2,907.3	2,100.0		−807.3	−807.3
Tool Design								
Liaison		3.0	17,341.9	17,341.9	16,945.0		−396.9	−396.9
Changes			43,849.2	43,866.1	40,070.0	16.9	−3,779.2	−3,796.1
Aerodynamics			2,058.6	2,058.6	2,330.0		+ 271.4	+271.4
Misc. Engineering			26,993.4	26,993.4	22,864.0		−4,129.4	−4,129.4
TOTAL OTHER DESIGN OPERATIONS		3.0	212,710.8	212,727.7	200,435.0	16.9	−12,275.8	−12,292.7
Aerodynamics Tests & Research	C1100		5,423.2	5,423.2	6,377.0		+ 953.8	+953.8
Structural Tests & Research	C1100		9,891.3	10,210.0	9,400.0	318.7	− 491.3	−810.0
Development Tests & Research	C1100	3.0	6,921.1	6,990.0	6,700.0	68.9	− 221.1	−290.0
Wind Tunnel Model	C1100	2.0	5,545.5	5,545.5	5,580.0		+ 34.5	+ 34.5
Mockup	C1100		3,555.4	3,555.4	3,555.4			
TOTAL RESEARCH & MOCKUP		5.0	31,336.5	31,724.1	31,612.4	387.6	+ 275.9	−111.7
Flight Test Engineering		29.5	6,779.8	6,779.8	4,950.0		−1,829.8	−1,829.8
GRAND TOTAL		37.5	397,137.1	397,541.6	382,342.4	404.5	−14,794.7	−15,199.2

FIG. 4:4.—Engineering hours report.

costs in man-hours. It is necessary only to multiply these values by the established engineering man-hour costs to arrive at money values. It will be seen that many of the original estimates have been exceeded, but only slightly. In general the original estimates were exceptionally accurate.

There are a variety of methods by which engineering costs can be forecast, analyzed, and recorded. The important factors are that every engineering department that expects to be efficient must establish and maintain budgets and provide a means of accumulating accurate, complete records of expenditures.

COST IMPROVEMENT

Another phase of engineering cost control is the reduction of manufacturing costs by intelligent application of the principles of production design. This can be termed "cost improvement" and has no direct relation to the cost-control method for maintaining engineering budgets. Cost improvement can best be accomplished through a production-engineering function that approves all designs in the development stage from the viewpoint of their production suitability. Additional checking and approval during the preparation of production drawings will tend to insure minimum manufacturing cost compatible with the required quality and performance.

Design analysis by a competent production engineer can often effect considerable savings by application of ideas that are obvious to a man trained in manufacturing methods but that might not occur to a design engineer. For instance, in some cases welded-steel assemblies may be more economical than drop forgings. Sometimes a forged part required in both left- and right-hand opposite forms can be made with a single die by an inexpensive machining operation on the rough forging. Occasionally a simple bracket can be sawed from extruded bar stock instead of using a forging or casting, with a considerable cost saving.

Limits on machined dimensions can frequently be increased with corresponding reduction in manufacturing cost, as the closer the limit the higher the cost. The designer should always ask himself the question "Would it be necessary to scrap this part if it were machined 0.001 or 0.002 in. over or under the limits that I have selected?" If the answer is "No," then add that much to the limits.

Cost comparisons can be used to advantage when two or more designs, parts, or items of equipment are possible for a particular application. These cost comparisons should be the responsibility of a person having a wide variety of production and procurement experience in order to insure accurate results. In no case should each group engineer

or supervisor be permitted to make his own cost comparisons for a variety of results are certain to be obtained, with many decisions being based upon partial knowledge of the facts.

COST COMPARISONS

Figure 4:5 shows a simple spacer that requires machining all over. The obvious material for this part is heavy-wall tubing. A careful analysis of the relative costs of machining the part from heavy-wall tubing or from solid bar stock indicated approximately a 30 per cent lower cost with bar stock because heavy-wall tubing is expensive. Bar stock is comparatively cheap and can be converted into a facsimile of

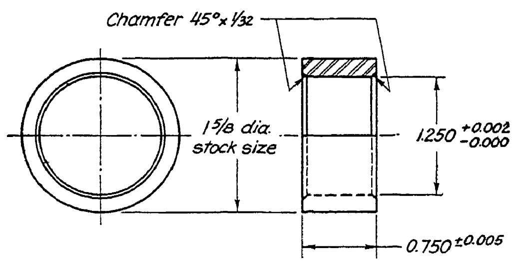


Fig. 4:5.—Cost comparison of two methods of manufacturing this small precision spacer revealed that the obvious method of using heavy-wall tubing is most costly.

heavy-wall tubing by a simple rough-drilling operation. Furthermore, the percentage of rejections due to defective material will be less with bar stock. Some heavy-wall tubing will develop longitudinal cracks during the machining process as a result of drawing strains released by the machining operations. This can be overcome only by annealing the tubing prior to machining, which introduces another operation and further increases cost.

Two designs for a torque-tube support bracket are shown in Fig. 4:6, one a forging and the other a welded assembly. In small quantities the weld assembly was 50 to 65 per cent less expensive, owing to the elimination of forging die and setup costs. For a quantity of 150 of these parts, forgings cost \$6.69 each, whereas the weld assemblies could be produced for \$2.10 each. The comparative costs for these designs were determined as follows:

Forging		Weld Assembly	
Material	\$1.29	Material	\$0.15
Labor	0.40	Labor	1.49
Die	5.00	Tooling	0.46
Cost per part	\$6.69	Cost per part	\$2.10

The money values given in the preceding example will vary, owing to changes in material and labor costs, but the relationship between costs of the two designs will remain substantially the same for a given quantity. On the other hand, should the quantity be increased to approximately 2,000 parts, the die cost per part would be reduced

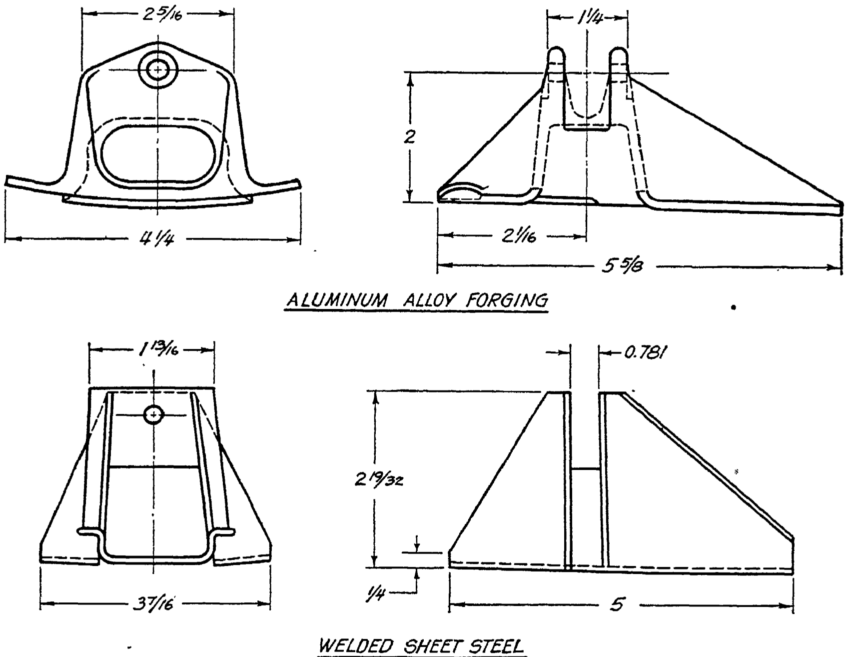


FIG. 4:6.—Investigation of two designs for this bracket showed that the weld assembly is considerably cheaper than the forging until large quantities are needed.

sufficiently to effect a saving by using a drop forging (see Appendix II for detailed cost-analysis and cost-comparison investigations).

METHODS IMPROVEMENT

Engineering management should be alert for opportunities to reduce departmental expenditures by methods improvement and work simplification. Existing methods should be analyzed to determine the purpose of each, followed by critical examination of the procedure used. Unnecessary operations should be eliminated and duplications consolidated. On the other hand, each method must provide complete, efficient coverage of the function involved. Often a particular function is accomplished in a certain manner because of precedent rather than necessity.

Prior to changing methods or procedures it is necessary to be certain that all facts have been ascertained. Considerable effort may be required to determine all facts regarding a particular function, including its effect upon other departments. Often the personnel responsible for a particular procedure have an imperfect understanding of its function, knowing only the superficial mechanics of its operation. In other cases a deliberate resistance to investigation of methods may be encountered. There is then a tendency to reveal only what is asked, with passive concealment of important facts not immediately apparent to the investigator. Methods investigations always demand persistence, diplomacy, and discretion. It is necessary to obtain *all* the facts, avoid antagonizing personnel, and refrain from compromising the methods-improvement program by proposing changes based upon imperfect data.

Work simplification is a companion of methods improvement. A study is made of the work executed by each employee in carrying out a procedure. Simplifications are made wherever this can be done without compromising the objective. Common savings accomplished by work simplification are elimination of duplicate records, consolidation of similar forms, and rerouting departmental work flow in order to eliminate needless handling.

SUMMARY

Cost control involves (1) establishment of budgets, (2) methods of collecting and allocating departmental costs, (3) compilation of factual data as a basis of cost estimates, (4) reduction of manufacturing costs by intelligent production design, and (5) methods improvement and work simplification to reduce the engineering overhead.

The first step is establishment of an engineering department budget, followed by individual budgets for each operating unit. These budgets must be revised in keeping with changes in the department work load. Each unit of engineering must operate within its current budget.

Costs are accumulated by establishing an account-number system where all engineering work is changed against account numbers issued by the cost-control activity. No engineering work must be accomplished until an account number is assigned to cover the job. Each employee furnishes the cost-control group a daily report showing the distribution of his day's work.

The secret of estimating accurately the cost of engineering projects lies in compiling accurate cost records over an extended period. Cost improvement is accomplished through a production engineering function that approves all designs in the development stage from the viewpoint of their production suitability.

CHAPTER 5

PLANNING

Engineering planning is the helmsman for the department, advising management on the feasibility of beginning new projects and directing departmental activities in order to insure completion of existing work. It occupies a high place in the departmental organization and has authority to establish work sequence and allocate personnel. Planning determines the work that can be accomplished within specified times and must enjoy the full confidence of management so that it can literally guide engineering activities. It is folly to establish an engineering-planning group and then refuse to be guided by their findings. This is the case if management insists upon scheduling new work when the existing work load makes impossible the accomplishment of additional tasks. When engineering management unwisely follows such a course, there will be no planning—only statistical recording of failure to meet schedules.

COORDINATION WITHIN THE ENGINEERING DEPARTMENT

Coordination of departmental activities is so closely related to planning that both functions must be handled by the same group in order to maintain effective control. Coordination provides analysis of all contracts, incoming requests, and new specifications to determine Engineering's responsibility in each. The responsibilities of each unit or group within Engineering is determined, together with a priority and requested completion date for the job. Planning ascertains the earliest practical completion date. If the requested completion date is mandatory, owing to customer demands or product deficiency, and cannot be met without either rescheduling equally important work or obtaining additional personnel, the matter is referred to management for decision.

After the job is scheduled, Planning maintains follow-up to insure that the schedule will be met, taking remedial action as necessary. The requester is notified of the completion date for the job, and a follow-up is maintained on each job. In many cases the data representing the completed job is forwarded by Planning to the requester.

Cost Control

Cost control plays an important role in engineering planning by providing a daily record of time expended on each project by every unit of engineering. Thus, Planning is able to balance the percentage of completion of each project against the man-hours expended in order to determine that the work is actually on schedule. Keeping a job on schedule involves completion of the work both within the required calendar time *and within the allocated man-hours.* If a job is completed on time, but with the expenditure of excessive man-hours, it usually means that another job has been slighted and will be late.

Basic Planning Functions

It becomes apparent that engineering planning involves four basic functions: (1) coordination, (2) estimating, (3) scheduling, and (4) cost reporting. The coordination, control, and scheduling functions properly become units or subdivisions of the planning group. Cost reporting, on the other hand, is a service function of the cost-control group, and this activity need not be a part of the planning group.

Before detailed operation of engineering planning is considered, the basic aims of that activity should be clearly defined. These are to (1) maintain current data on the department's work capacity; (2) establish schedules, completion dates, priorities, and effectivities for all work; (3) control authorization of *all* work accomplished; (4) guide engineering supervisors in planning work; (5) maintain current progress records for all work; (6) exercise remedial action to prevent lagging behind schedule; (7) advise management of delays beyond the control of Planning; (8) maintain complete case histories as the basis for future planning; and (9) determine current and future man-power requirements in the light of current and future work loads.

In a small engineering department the entire planning activity may be handled by a single person. Large departments require a correspondingly larger planning group, directed by a planning manager and having personnel individually responsible for coordination, estimating, and scheduling functions. Operation of the planning group will be the same in each case since the basic aims are identical.

Detailed methods, forms, and routine established to implement operation of the planning unit will vary with each engineering department—according to the nature of the product, caliber of available personnel, and top management preference. Therefore, no attempt is made here to establish the detailed mechanics of engineering planning. Instead,

the operating plan of each basic function is emphasized. Operational details can be established to suit individual engineering department needs.

COORDINATION

Planning begins with coordination. The coordination unit receives all incoming correspondence, requests for data, change requests, and specifications. These are recorded and analyzed before action is taken by the engineering department. It is determined whether the correspondence or other request requires work by direct-labor personnel and thereby affects the departmental work load or simply demands an answer from an engineering executive.

In the latter case the request is assigned to a due date and directed to the executive best able to supply the answer. Follow-up is maintained to make certain that the answer is forthcoming by the due date. The answer may be submitted to the chief engineer for approval and signature prior to forwarding to the requester, or perhaps only a copy is forwarded to the chief engineer, depending upon the plan for handling outgoing correspondence.

When the request requires expenditure of direct labor, the coordination unit informs the estimating unit of the request; its general effect upon engineering, including the estimated engineering work required; when the job should be completed; and the priority, or relative importance, of the job. Establishment of a priority is vitally important. This guides the scheduling unit in fitting the new job into the structure of existing jobs and permits intelligent decisions in rescheduling existing jobs to permit rapid completion of important new assignments.

In some cases the requested completion date cannot be met, owing to a heavy load of important current work. Coordination must then effect a satisfactory compromise with Scheduling in order to arrive at an adjusted due date. The effective serial number of a requested change affecting production of a company product is obtained from the manufacturing-planning department. Coordination is then in a position to inform the requester of the action to be taken, scheduled completion date for engineering, and in some cases the effective serial number of the change on the production line.

Master-change Record

When the requester's approval is required before actual engineering can begin, the data is forwarded to the requester on the basis of completion within a specified time after receipt of approval. Further action

is held in abeyance while awaiting confirmation. These cases often occur when the requester is the customer and, in particular, when that customer is the government. Forwarding of data regarding requested changes is handled by a master-change record (see Fig. 5:1) system in the case of government contracts involving aircraft, where the MCR

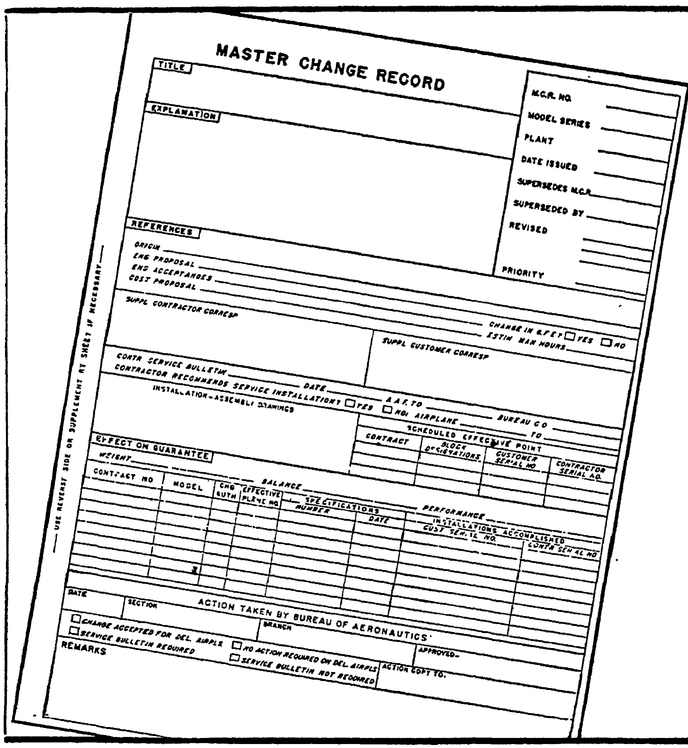

MASTER CHANGE RECORD
TITLE
EXPLANATION
M.C.R. NO.
MODEL SERIES
PLANT
DATE ISSUED
SUPERSEDES M.C.R.
SUPERSEDED BY
REVISED
PRIORITY
REFERENCES
ORIGIN
ENG PROPOSAL
ENG ACCEPTANCES
COST PROPOSAL
SUPPL CONTRACTOR CORRESP
CHANGE IN A.F.E.P. ☐ YES ☐ NO
ESTIM MAN HOURS
SUPPL CUSTOMER CORRESP
CONTR SERVICE BULLETIN
CONTRACTOR RECOMMENDS SERVICE INSTALLATION? ☐ YES ☐ NO
DATE
A.A.F. TO
BUREAU C O
INSTALLATION-ASSEMBLY DRAWINGS
NO. AIRPLANE
TO
SCHEDULED EFFECTIVE POINT
CONTRACT
BLOCK DESIGNATIONS
CUSTOMER SERIAL NO
CONTRACTOR SERIAL NO.
EFFECT ON GUARANTEE
WEIGHT
BALANCE
CONTRACT NO
MODEL
CHG AUTH
EFFECTIVE PLANE NO
SPECIFICATIONS NUMBER
DATE
PERFORMANCE
INSTALLATIONS ACCOMPLISHED
CUST SERIAL NO
CONTR SERIAL NO
DATE
SECTION
ACTION TAKEN BY BUREAU OF AERONAUTICS
BRANCH
☐ CHANGE ACCEPTED FOR DEL. AIRPLS
☐ SERVICE BULLETIN REQUIRED
☐ NO ACTION REQUIRED ON DEL. AIRPLS
☐ SERVICE BULLETIN NOT REQUIRED
APPROVED
ACTION COPY TO
REMARKS
USE REVERSE SIDE OR SUPPLEMENT BY SHEET IF NECESSARY

FIG. 5:1.—Master change record, for revisions negotiated with the customer on government contracts, is also used by the customer to request changes.

form is used both by the customer to request changes and by the contractor to forward data relating to changes. A master-change record progress report (see Fig. 5:2) is maintained by Coordination as a record of all MCR's and the status of each.

An engineering-load record similar to that shown in Fig. 5:3 should be maintained by Planning and copies issued to all interested departmental executives once each week. This record lists all active engineering work orders and keeps management informed of the over-all load of the engineering department and the progress being made on each job. The engineering-load record is a strictly management report, and the work

load for each individual engineering group should be issued separately, using a form similar to the group schedule and status shown in Fig. 5:4. The group-load record lists all active work orders affecting a particular group, showing the group progress on each, and keeps all supervisors informed of the work load for their groups.

MASTER CHANGE PROGRESS REPORT

Date________ Model________
Supersedes________ Page____ of____

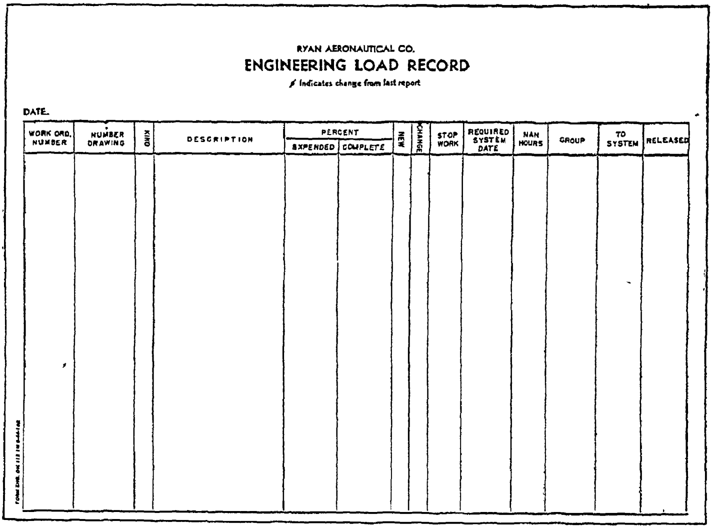
M.C.R. NUMBER	TITLE OF CHANGE	SCHED EFFECT AIRPLANE		ENGINEERING RELEASE		PRODUCTION		MATERIAL		TOOLS		RELEASE TO SHOP	
		No	Date	Sched	Act	Sched	Act	Sched	Act	Sched	Act	Sched	Act

FIG. 5:2.—Master-change-record progress report furnished interested departments requiring information on current progress of master changes.

The load and schedule records in combination with a correspondence-assignment record are used to maintain follow-up on all active engineering work. This follow-up must be aggressive in order to insure prompt action in each case, and Planning must be empowered by management not only to request but also to *demand* that the assigned work is accomplished by the scheduled dates.

CONTROL OF SPECIFICATIONS

A company engaged in government contracts must follow numerous specifications relating to design, materials, and processes. These are frequently changed by the government, and new or revised specifications are being constantly received by the contractor. Control must be exercised over their usage in order to prevent confusion within the



RYAN AERONAUTICAL CO.

ENGINEERING LOAD RECORD

✓ Indicates change from last report

DATE

WORK ORD. NUMBER	NUMBER DRAWING	KIND	DESCRIPTION	PERCENT EXPENDED	PERCENT COMPLETE	NEW	CHANGE	STOP WORK	REQUIRED SYSTEM DATE	MAN HOURS	GROUP	TO SYSTEM	RELEASED

FIG. 5:3.—Engineering-load record lists all active work orders, keeps supervisors informed of work loads, and keeps management informed on work loads and progress in each engineering group.

contractor's organization and to avoid needless expense due to change in manufacturing methods and materials to conform to new specifications.

The coordination unit exercises control over new and revised specifications, and these are screened before release to the engineering library and other files within the factory. A list of new and revised specifications, showing the effect of each, is periodically released to all engineering supervisors and executives. At the same time the list of effective design specifications for each active project is revised accordingly.

The choice of using a new design specification is governed primarily by whether or not its use is mandatory and secondly by the possibility of its usage being to the advantage of the company. New and revised material and process specifications are normally used without hesitation, as it is rare for changes in these to have far-reaching effects. On the other hand, attempts to purchase material to obsolete specifications

or to obtain subcontracted process work to obsolete specifications will invariably result in complications.

Forwarding of Correspondence and Other Data

Coordination also forwards all outgoing correspondence and data or receives copies of correspondence to permit closing out follow-up

FORM [illegible]

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
DEVELOPMENT ENGINEERING GROUP
SAN DIEGO CALIFORNIA

SCHEDULE AND STATUS

MODEL ______ GROUP ______	ESTIMATED		SCHEDULE				PER CENT COMPLETE			STATUS		SEE NOTE
DESCRIPTION	NO OF DRAWINGS	MAN HOURS	STARTING DATE	TO CHECK	TO STRESS	RELEASE DATE	SCHEDULED	ACTUAL		AHEAD %	BEHIND %	

70% REPRESENTS SENT TO CHECKER. 80% SENT TO STRESS.
90% SENT TO PROJECT ENGINEER. 100% RELEASED BY ENGINEERING.

GROUP MODEL

PAGE OF

FIG. 5:4.—Group-schedule status report shows the work-load for each engineering group and the progress on all active work orders affecting group.

records. The actual forwarding of prints to the factory, however, is accomplished by the engineering release group, and Coordination receives a copy of each job ticket releasing prints during the progress of a job. The scheduling unit informs Coordination when a job is complete. Forwarding of prints to destinations outside the factory, however, is handled by Coordination.

ESTIMATING

The next phase is actually planning the job, followed by work orders to authorize accomplishment of the actual work. This is done by the estimating unit, which analyzes each job to determine the required work and segregates this into the individual responsibilities of each engineer-

ing group. Some of the operations involved may be possible of concurrent execution; others must be consecutive. In each case the routing is considered when planning the job and estimating man-hours for each operation. The person or office responsible for managing the job to insure final consolidation of its parts to form the whole is determined and noted on the work order.

Preliminary Work Order

A preliminary work order, showing desired due dates and estimated times for each phase and the complete job, is forwarded to the scheduling unit. If the current engineering work load permits integrating the new job, the preliminary work order is approved by Scheduling and returned to Estimating. Frequently the current load is such that the requested date cannot be met. Then the coordination, estimating, and scheduling unit supervisors must confer and arrive at a due date that can be met and still satisfy the need for the new job.

When the due date cannot be met in a satisfactory manner, the matter is referred by the planning manager to the chief engineer for a decision. Such cases result when the current work load prevents addition of new work. This condition can be solved by (1) postponing the new work, (2) rescheduling current work to provide time for the new job, or (3) obtaining additional personnel. In any case the action required becomes a management decision based upon the facts presented by Planning.

Revised Work Order

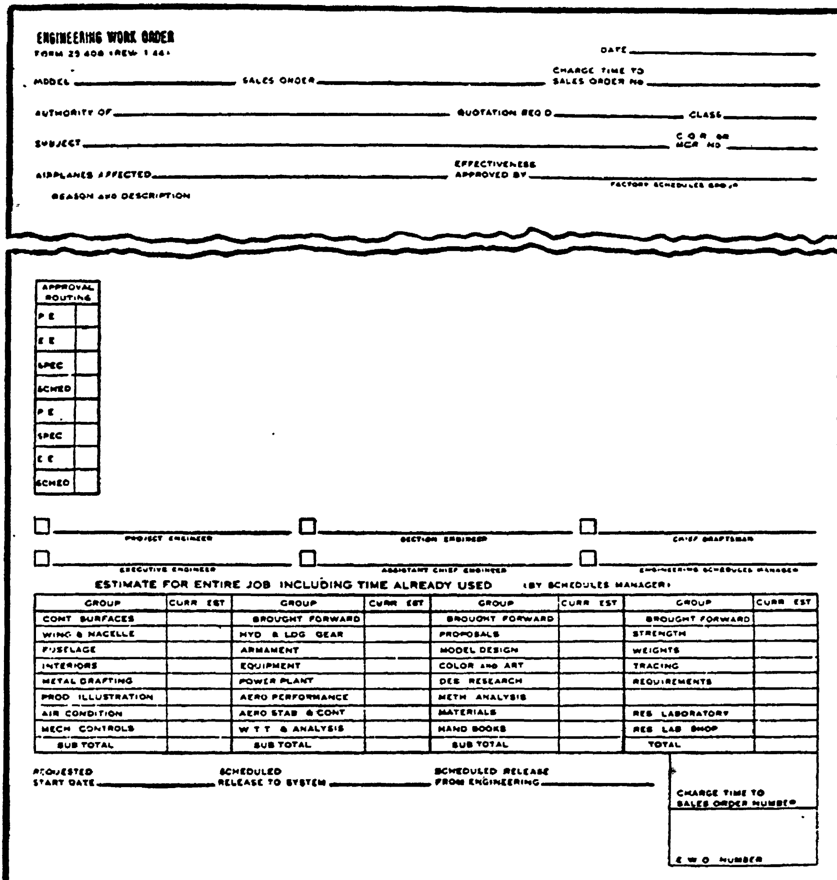
The corrected work order is submitted to the chief engineer for approval, followed by issuance of copies to all engineering supervisors affected by its provisions. Serial numbers for the recording of time expended against the work order are shown for each engineering group.

Revised work orders are occasionally required because of changes in the nature of the job or schedule changes. These are issued upon notification from the coordination unit. Coordination is kept informed of design problems by the executive in charge of the job and of necessary schedule changes by the scheduling unit. These revised work orders are also approved by the chief engineer prior to release.

Records and Statistics

Records are maintained of estimated and actual times on all jobs. Investigation of causes is made when a job measureably exceeds or falls

short of the estimate. These data on actual time expenditures for various jobs serve as the basis for future planning. Time estimates will become increasingly accurate as more factual data is accumulated,



ENGINEERING WORK ORDER
FORM 25 408 (REV 1 44)

DATE ______

MODEL ______ SALES ORDER ______ CHARGE TIME TO SALES ORDER NO ______

AUTHORITY OF ______ QUOTATION REQ D ______ CLASS ______

SUBJECT ______ C O R OR MCR NO ______

AIRPLANES AFFECTED ______ EFFECTIVENESS APPROVED BY ______ FACTORY SCHEDULES GROUP

REASON AND DESCRIPTION

APPROVAL ROUTING	
P E	
E E	
SPEC	
SCHED	
P E	
SPEC	
E E	
SCHED	

☐ ______ PROJECT ENGINEER ☐ ______ SECTION ENGINEER ☐ ______ CHIEF DRAFTSMAN

☐ ______ EXECUTIVE ENGINEER ☐ ______ ASSISTANT CHIEF ENGINEER ☐ ______ ENGINEERING SCHEDULES MANAGER

ESTIMATE FOR ENTIRE JOB INCLUDING TIME ALREADY USED (BY SCHEDULES MANAGER)

GROUP	CURR EST	GROUP	CURR EST	GROUP	CURR EST	GROUP	CURR EST
CONT SURFACES		BROUGHT FORWARD		BROUGHT FORWARD		BROUGHT FORWARD	
WING & NACELLE		HYD & LDG GEAR		PROPOSALS		STRENGTH	
FUSELAGE		ARMAMENT		MODEL DESIGN		WEIGHTS	
INTERIORS		EQUIPMENT		COLOR AND ART		TRACING	
METAL DRAFTING		POWER PLANT		DES RESEARCH		REQUIREMENTS	
PROD ILLUSTRATION		AERO PERFORMANCE		METH ANALYSIS			
AIR CONDITION		AERO STAB & CONT		MATERIALS		RES LABORATORY	
MECH CONTROLS		W T T & ANALYSIS		HAND BOOKS		RES LAB SHOP	
SUB TOTAL		SUB TOTAL		SUB TOTAL		TOTAL	

REQUESTED START DATE ______ SCHEDULED RELEASE TO SYSTEM ______ SCHEDULED RELEASE FROM ENGINEERING ______

CHARGE TIME TO SALES ORDER NUMBER

E W O NUMBER

FIG. 5:5.—Typical engineering work order. On extensive jobs, a detailed listing of all new, revised, and canceled drawings involved accompanies the work order.

assuming that reasonable correction is made for detail variations between similar jobs.

All estimating should be done on the basis of 80 per cent effective application of labor. The remaining 20 per cent is allocated to unforeseen contingencies, such as absentees, illness, or personnel changes. Thus, when man-hour estimates are converted to calendar weeks, a 32-hr. effective work week is assumed for departments operating on a 40-hr. normal work week.

The time required to accomplish various types of engineering work will vary greatly with different companies, being greatly influenced by caliber of personnel and management efficiency. It is not practicable to give more than comparative data on engineering time expenditures. Experience of several companies engaged in the manufacture of large, complex vehicles, for instance, shows the following relationship between layout and detail drafting time:

	Nature of engineering work		
	Structural design	Equipment installations	Mechanical design
Layout time, %..	30	50	70
Detail time, %...	70	50	30

Development engineering is defined as preliminary design of the product, engineering necessary to construct an experimental article, and testing of the article. Records indicate that development engineering normally represents 30 per cent of the total engineering expenditure.

Checking of engineering drawings requires a minimum of 10 per cent of the time expended to prepare the drawings. Thus, personnel plans for an engineering department should be based on a minimum of 1 checker for every 10 draftsmen.

Some engineering departments use drawings prepared upon paper or cloth exclusively, and prints of drawings requiring preparation of developed patterns are sent to the loft or template departments for accomplishment of this work. Other engineering departments use metal drawings for such parts, and the developed template is accurately drawn upon the metal sheet. Copies are reproduced by photographic or some other suitable method and forwarded to the shop for use as templates. Metal drawings require considerably more time than those prepared on paper or cloth. The records of one large aircraft company indicate that metal drawings require 50 per cent additional drafting time, 80 per cent more checking time, and 10 per cent additional engineering floor space.

Estimating a Job

During preparation of time estimates for a new job it is necessary for the planning unit to consult with the engineering supervisors affected by the job. In the case of an entirely new project, where records of similar work do not exist, it follows that Planning must be guided by the

viewpoints of these supervisors, modified by an understanding of the relative experience of each supervisor and his personnel. The experience factor is vitally important. For instance, one company expended 57 man-hours per drawing during the design of a complex twin-engine

WEEKLY ENGINEERING SUMMARY
Project 19

Date 11/20/43

Proj. 19 Active Dwgs.	Proj. 17 Dwgs. 19 Req.	Proj. 12 Dwgs. 19 Req.	Proj. 10 Dwgs. 19 Req.	Active Dwgs. 19, 17 12,10	Est. Total Dwgs.	Design Section	Total Rel. to Blue Print	%	No. 19 Dwgs. Rel. to Plan'g.	No. 17 Dwgs. Rel. to Plan'g.	No. 12 Dwgs. Rel. to Plan'g.	No. 10 Dwgs. Rel. to Plan'g.	%
336		259	3	598	593	Fuselage			313		242	3	
198		58		256	256	Monocoque			180		58		
381		51		432	432	Outer Wing			356		51		
348		3	1	352	352	Inner Wing			345		3	1	
178		184		362	362	Empennage			177		184		
86		139	4	229	229	Controls			85		139	4	
190		6		196	196	Landing Gear			190		6		
30		0		80	80	Hydraulics			80		0		
352	1	32	12	407	407	Power Plant			352	1	32	12	
16		39		55	55	Instruments			16		39		
141	1	68	11	221	221	Equipment			135	1	68	11	
60		107		167	167	Armament			60		107		
2376	2	946	31	3355	3355	Totals	3246	96.8	2289	2	929	31	96.6

System Checkup

Location	Last Week	This Week
Release Clerk	0	0
Check Group	9	0
Group Corrections	0	0
Stress Group	0	0
Weights Group	0	0
Project Engineer	0	4
Chief Project Engineer	0	0
Navy Office	0	0
Total	9	4

Summary Totals

	Last Week	This Week
Total approved prints to Planning	3266	3241
Prints delivered to Planning	13	25
Cancelled Drawings	0	0
Net Increase approved prints	13	25
Prints in System	9	4
In Blue Print	0	5
Total Delivered and in System	3275	3250
Total Active Drawings	3309	3355
Balance in Work	34	105

FIG. 5:6.—Engineering summary of drawing releases, issued daily or weekly, indicates progress in release of new drawings for all projects. Planning in this example refers to Manufacturing Planning in the factory.

airplane, using experienced personnel. Another company, forced to hire large numbers of inexperienced personnel owing to wartime housing problems, expended 108 man-hours per drawing during the design of an airplane of comparable complexity.

Occasionally it will be found that a supervisor considers estimating impossible because too little is known about the job. In such cases the

supervisor will have to agree that there is a certain minimum time that the job must require and a definite maximum that will not be exceeded.

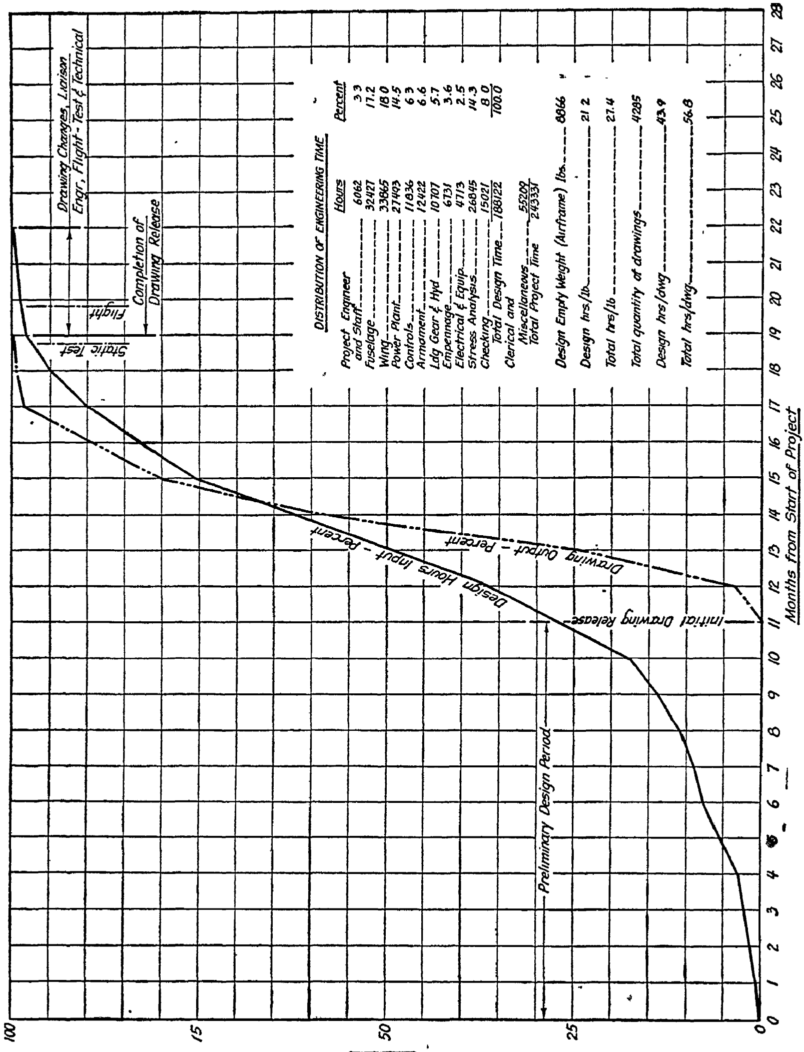


FIG. 5:7.—Cumulative time and drawing release during design of experimental twin-engine fighter airplane.

With this basis it is usually possible to arrive at a reasonably accurate intermediate value.

When an entirely new project is first planned, the calendar time indicated is often unreasonably long, and executives and supervisors may have to be consulted to arrive at a method of shortening the time

span. This can usually be done by telescoping the schedule through concurrent accomplishment of various phases by exchange of advance information among groups and departments. The release of advance information must be controlled and should be made a responsibility of

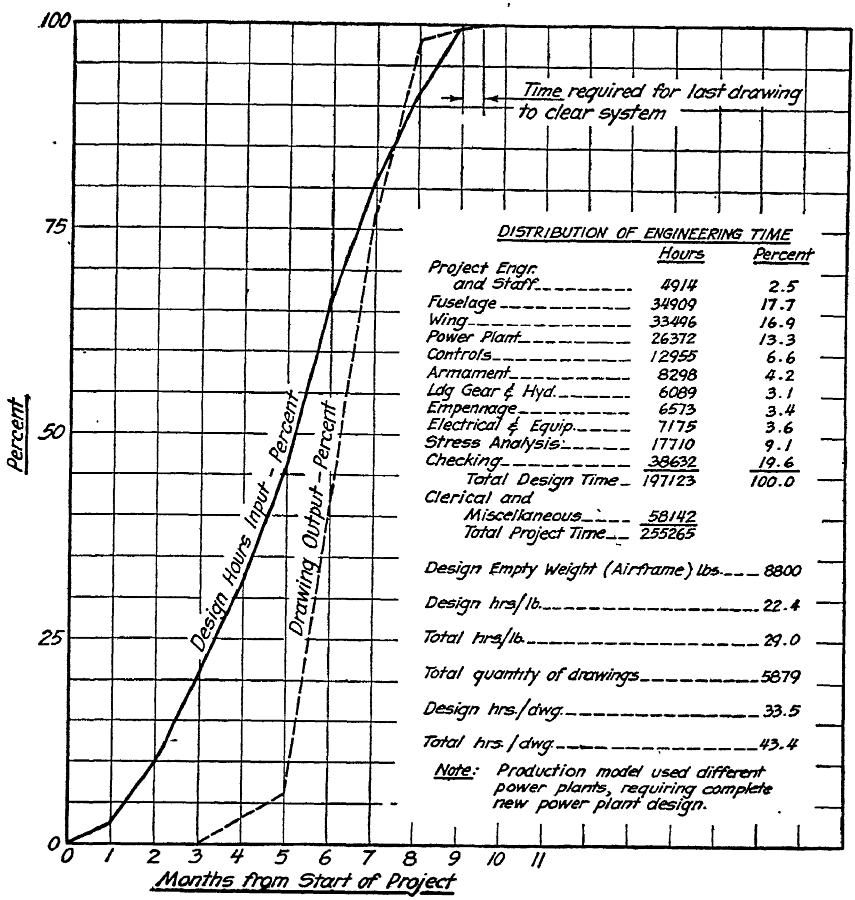


FIG. 5:8.—Cumulative time and drawing release during design of production twin-engine fighter airplane based upon experimental design recorded in Fig. 5:7.

the person in charge of the project, so that time will not be lost on work based on erroneous or incomplete advance information.

A vexing problem that frequently arises is determining when a complex project is actually complete and all information released. This condition can be avoided by spending sufficient planning time and providing a detailed job breakdown on the work order, followed by revision of the work order whenever requirements change for any phase.

Considerable detail is required to break down the work order for a large project satisfactorily. For instance, the order authorizing engineering on a certain single-engine, two-place attack airplane lists 364 layout, installation, and assembly items for the job and shows the estimated quantity of drawings and man-hours for each item. This list was revised and reissued when necessary, and upon all items being complete the project was obviously completed.

In Fig. 5:7 is data on cumulative man-hour expenditures and drawing releases for an engineering project involving design of the experimental model of a twin-engine fighter airplane, with data in Fig. 5:8 on the production redesign of the same airplane. More time was used for the production redesign than was expended upon the experimental version. This is frequently the case with extensive design projects on complex articles—for emphasis is too often upon completing the experimental article, with corresponding failure to produce accurate engineering drawings.

SCHEDULING

The scheduling unit is the pivotal point of the entire engineering-planning function since it must determine the feasibility of all proposed work and expedite all current jobs. Effective scheduling requires realistic thinking based upon factual data. Information furnished management regarding the department's work capacity and possibility for meeting due dates must be accurate and not colored by wishful thinking. Management, on the other hand, must be willing to accept this information as basic and not insist upon accomplishment of the impossible.

Scheduling must also be flexible. The most carefully prepared schedules may be suddenly upset by unforeseen changes or failures of experimental designs. When this occurs, the scheduling unit must be able to improvise or reschedule rapidly to meet the new conditions.

Basic scheduling requires records of the work capacity of each group or section within Engineering and of the department as a whole. These records are based upon the type of work, such as layout drafting, detail drafting, weight analysis, strength analysis, drawing checking, parts listing, and technical writing. Records for all current work are also necessary, showing the work load for each engineering employee, group, and section and for the department as a whole. Obviously, the essence of scheduling is to maintain the proper balance between work capacity and work load.

The man-hour-distribution and drawing-release chart shown in Fig. 5:9 provides an interesting study of the relationship between work ca-

pacity and work load. It indicates maintenance of a direct relationship between hours per month input and drawings per month output during

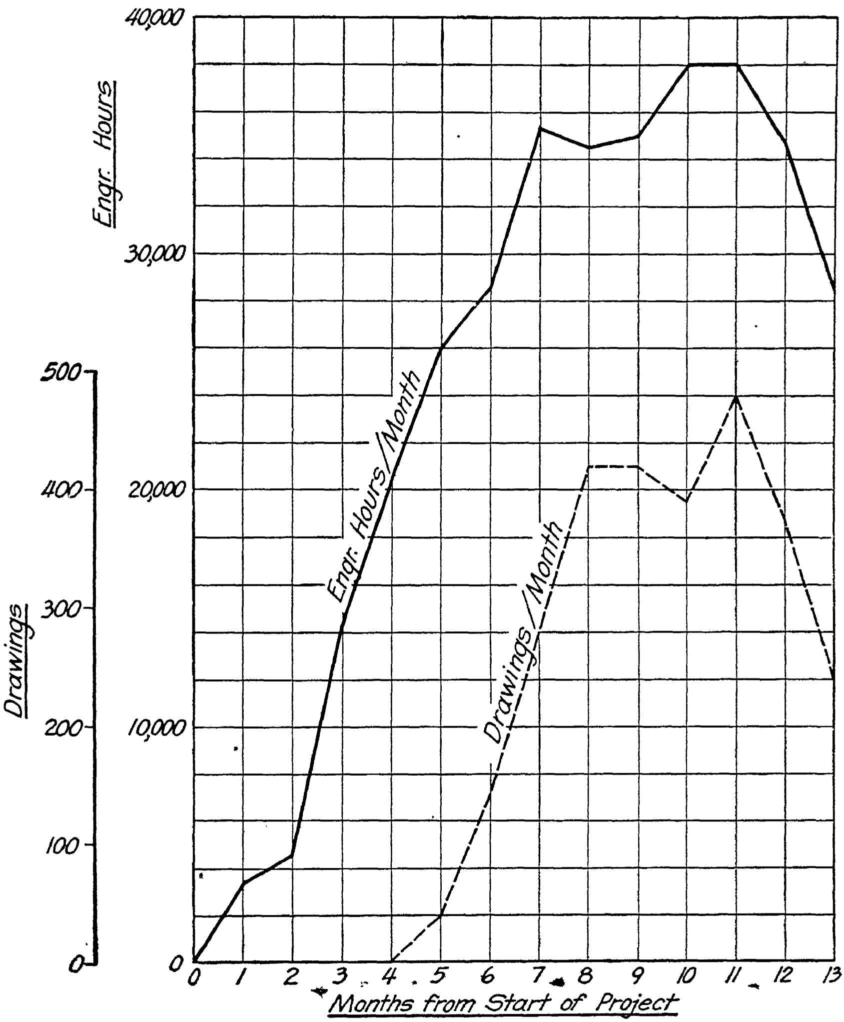


FIG. 5:9.—Man-hour distribution and drawing release during design of experimental airplane. Typical for extensive, complex engineering project.

the first five months of drawings release (fourth through ninth month after start of project). At this point a considerable increase in hours per month input does not reflect additional drawing output but indicates instead a sharp decrease during the tenth month. This is the re-

sult of employing comparatively inexperienced personnel to effect the increase during this period. Previous increases in hours per month input were effected by transferring existing personnel to the new project. This change in the source of additional labor required experienced personnel to divert time from productive labor to orientation of new employees. The increase in output shown during the following month is the result of improved efficiency as new employees become familiar with the project. The obvious conclusion to be drawn from this record is that simple numerical increase of personnel on a given project does not guarantee an immediate improvement in engineering output.

Progress Records

Progress records should be kept for each active work order, showing actual completion against scheduled completion with reference to both man-hours and calendar days. A visual chart similar to that shown in Fig. 5:10 can be used to provide a "mass impression" of a given project's progress for the benefit of management and engineering supervisors. Additional detail records will show the exact cause of delays or other trends. The progress chart lists the main units of the work order, using horizontal bars to indicate the time span allocated for completion of each. Each day in the time span of a particular unit is arbitrarily considered as representing an equivalent percentage of the work required to complete the unit. For instance, if 20 working days are allocated for completion of a project unit, then 5 per cent of the work should be completed and released each day to maintain the schedule.

A second bar of contrasting color is placed directly below the time-span bar and indicates daily progress. The relationship between each pair of bars indicates the general status of the project. Units with a progress bar extending to the current date line are on schedule; those extending beyond are ahead of schedule; and all failing to reach the current date line are behind schedule. The current date line should be a ribbon or tape that is advanced daily, and the progress chart should be prepared on a sufficiently large scale to permit rapid reference.

In the example shown in Fig. 5:10 it is immediately obvious that "Gun Sights" are lagging sufficiently behind schedule to demand immediate remedial action. On the other hand "Furnishings" is well ahead, indicating excessive application of man power. The other units are either on schedule or slightly ahead, with the exception of "Electrical." The deficiency here is so slight that immediate action should not be taken. If the condition becomes chronic or grows worse, then steps must be taken to rectify the situation.

Detail Records

Other records show the progress of all drawings through the engineering-department release system (see Fig. 5:6). Whenever schedules are delayed or when possible delay can be foreseen, remedial action is taken to place the job on schedule. This action may involve reallocation of

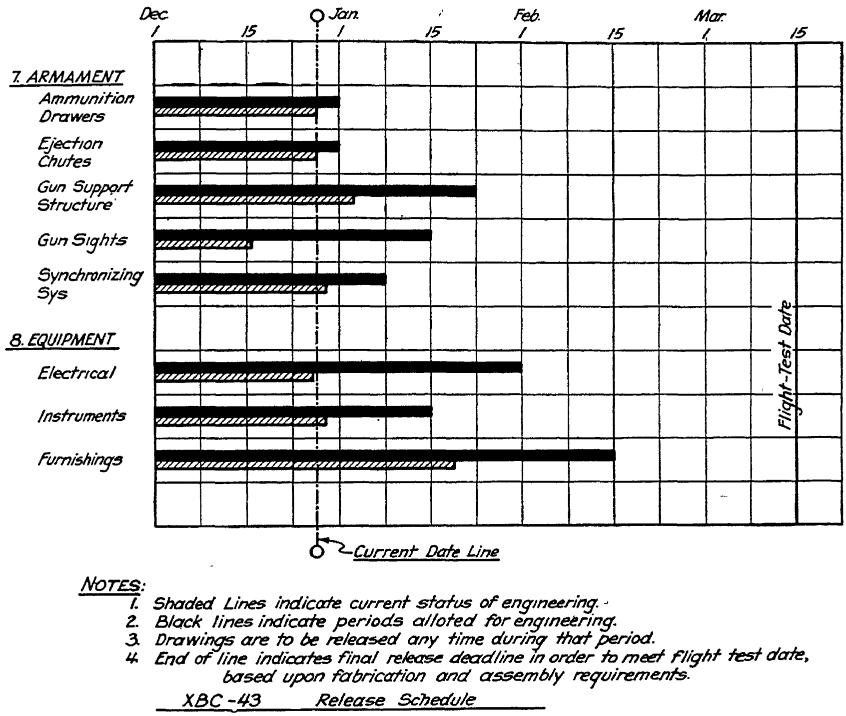


FIG. 5:10.—A portion of a visual drawing-release schedule and status record for a single-engine advanced-training airplane-design project.

personnel, authorization of overtime work for a brief period, allocation of a portion of the job to another group, or the procurement of additional personnel.

Accumulated factual data permits Scheduling to forecast future manpower requirements on the basis of known and estimated future work loads. This forecast of the future requirements is maintained for a minimum period of 6 months, in addition to the record of current manpower requirements.

All engineering timecards should be checked daily by Scheduling, prior to forwarding to the timekeeping department. Erroneous time

charges can be corrected and called to the attention of the employee at fault. Individual employee time expenditures are posted at this stage. The timecards are then forwarded for tabulating, and an accumulated record of the charges is available on the following day. Scheduling checks each day with all engineering groups and sections to ascertain the progress made on each engineering work order.

These records of work capacity, load, and progress permit determination of the feasibility of requested due dates on new work orders. Each preliminary work order is checked against these data and the due date revised accordingly. When the revised due date is not acceptable to Estimating or Coordination, the scheduling unit must consult with all concerned to arrive at a satisfactory compromise.

Scheduling Minor Jobs

In addition to the planned jobs there are always a variety of small, routine drawing changes that must be accomplished by the various drafting groups. These are usually the result of minor change requests (see Chap. 12) and the incorporation of advance drawing changes. All that require less than 25 man-hours are not scheduled but are appraised by Estimating and logged by Scheduling so that the group time allocation for routine changes will not be exceeded.

A blanket time allocation for routine changes, made for each group and section every week, is corrected when necessary on the basis of actual expenditures. A logical basis for this estimation is the assumption that each drawing will have two advance drawing changes and one change request during its active life and that an average of four engineering hours will be required to incorporate each of these.

Drawing-change Schedules

Completion of the initial drawing releases for the project, as shown by job tickets forwarded from the engineering release group, does not mean completion of the engineering work on the project. Time must be provided for major changes during the life of the project. Experience indicates that the total change time, both major and minor, accumulating between completion of the initial drawing release and completion of the first production article will equal the total time spent to complete the initial drawing release.

After completion of the first production article, the change time will drop sharply to stabilize during a long production run at a value for each production unit of approximately 0.1 per cent of the engineering

time spent to complete design of the first production article. Thus, if a given project required 200,000 engineering hours to complete the first production article, it is reasonable to assume that 200 hr. of engineering will be spent for each production article during manufacture. These data should not be used as a factual basis for all scheduling as they relate only to a certain product and particular engineering department. Other products and factories may require entirely different values. In every case, the only satisfactory criterion is factual data relating to the particular product and department and accumulated over a sufficient period to become significant.

The information given here is intended to show only the requisites for engineering planning. All details, records, and forms necessary for successful operation of a particular engineering planning department must be based upon conditions prevalent in the engineering department.

CHAPTER 6

STANDARDS

Standards should be established to govern drawing preparation, engineering procedures and methods, standard parts, and designs. A method of releasing this information to all concerned must be developed, followed by inauguration of a system to make sure that copies of revised standards reach all recipients of the original information. One person in Engineering should be designated to control preparation, distribution, and revision of standards.

When standards are carefully prepared, comprehensive in nature, and faithfully observed, there will be no need for engineering personnel to spend time debating the proper method of preparing a drawing or the correct procedure for a particular condition. Standards should be published in suitable form (see Figs. 6:1 through 6:5, and 6:16 and 6:17), and copies distributed to all personnel affected by their provisions. The information contained in these publications should be followed without deviation other than those changes authorized by the engineering-standards supervisor in cases where the standards are found to be deficient.

When a standard is found undesirable, inadequate, or in error, a revision to correct the deficiency should be promptly issued. Chronic violations due to uncorrected deficiencies cannot be tolerated as the entire purpose of standards is then defeated. Standards are intended to assist, rather than confuse, functioning of the engineering department by providing information that eliminates operational problems and duplication of design work.

CLASSES OF STANDARDS

The standards normally prepared for and used by an engineering department relate to (1) policy and procedure affecting both engineering and other departments, (2) policy and procedure primarily affecting engineering, (3) drafting practices, (4) recommended design practices, and (5) standardized company parts. These are usually issued as separate publications, identified as

Standard-practice instructions
Engineering-procedures manual
Drafting-room manual
Design handbook
Standard-parts handbook

Standard-practice instructions are usually issued by the company industrial-engineering or methods department and cover operation of

CONSOLIDATED VULTEE AIRCRAFT CORPORATION
VULTEE FIELD DIVISION

DIVISION STANDARD PRACTICE

NUMBER 2 ISSUE 7
SUPPLEMENT -- ISSUE
PAGE 1 OF 5 PAGES
DATE ISSUED

SUBJECT: MASTER AUTHORIZATION SYSTEM

Please destroy all copies of D.S.P. 2, issue 6, dated November 12, 1943.
This issue 7 obsoletes issue 6.

I PURPOSE

To establish the procedure for requesting, obtaining approvals for, preparing and distributing Master Authorizations.

II DEPARTMENTS AFFECTED

A. All departments of Vultee Field Division

The following departments are affected by additional instructions:

B. Plant Engineering
C. Industrial Engineering
D. Accounting
E. Contract

III PROCEDURE

A. All departments of Vultee Field Division (General Office Depts.' See Suppl. 2)

1. Scope, Classification and Method of Making Request

The Master Authorization System, through the use of the Master Authorization (form #102-19-1), shall control work performed and money spent at Vultee Field Division and shall cover the following:

a. Sales Contract M.A. — A Sales Contract (Production) M.A. is one issued to cover all items of direct cost which will be charged against a sales contract.

On the basis of a customer's purchase order or sales contract executed by the Contract Department, a M.A. shall be issued by the Master Authorization Group according to Supplement 1 of this instruction.

b. Capital Expenditure M.A. — A Capital Expenditure M.A. shall be required to cover the purchase, construction, sale, trade-in, transfer or scrap of any item of machinery, equipment, or other facility, regardless of amount, also for the installation charges on equipment transferred from another division.

PREPARED BY H. K. Teeter DATE 1-27-45

APPROVED BY G. A. Irvin
G. A. Irvin

DATE

AUTHORIZED BY Carl M. Coslow
DIVISION MANAGER

131-30-2

FIG. 6:1.—Standard practice instruction.

basic interdepartmental functions. They primarily concern department heads responsible for their conformance, and copies are issued only to department heads and key departmental executives. The engineering-procedures manual provides detail direction of basic functions involved in operation of the department, and copies are normally fur-

nished all engineering executives and supervisors. Copies of the drafting-room manual, design handbook, and standards handbook should be supplied all design and drafting personnel.

ESTABLISHMENT OF ENGINEERING PROCEDURES

Each engineering procedure is created to control a basic operational function of the department in the most efficient manner. Prior to establishing a procedure it is necessary to analyze the nature of the function involved, its effect upon Engineering and other departments, facilities available for its operation, and existing methods used to effect its working.

Wherever practicable a large portion of the existing methods should be incorporated in the new procedure in order to avoid drastic changes that may result in disruption of the function involved. Improved methods should be introduced as smoothly as possible so that the effect is one of continuous improvement in departmental efficiency rather than abrupt dislocations.

Following formulation of a procedure it is advisable to call a meeting of all executives and supervisors who will be affected in any manner by its provisions. The proposed procedure should be thoroughly discussed to locate and correct all defects and effect a thorough understanding of its operation and necessity. Full advantage should be taken of constructive criticism. When such meetings are properly handled, the executives and supervisors present will feel that they have played a part in creating the procedure. This will assist in obtaining the necessary cooperation during application of the method controlled by the procedure.

The person responsible for establishing procedures must be able to justify the need for every provision and rule. Personnel responsible for the application of procedures cannot be depended upon to adhere consistently to their provisions unless the necessities for them are clearly understood. In every case the major problem in establishing engineering procedures is not preparation of a practicable, efficient method but rather obtaining the full cooperation of all personnel responsible for successful operation. Unless this can be done, the best procedures will fail. The importance of this factor must not be underestimated, and every possible step must be taken to overcome the normal human aversions to (1) change of any kind and (2) regulation of any nature.

PROCEDURES MANUAL

The completed procedure should be issued, after review and approval, in a form similar to the example shown in Fig. 6:2, with copies distributed to all executives and supervisors concerned with its provisions.

These procedures should be accumulated in a "procedures manual," which then becomes the standard governing all procedures, policies, and

PROCEDURES MANUAL

ENGINEERING DEPARTMENT

INTERSTATE AIRCRAFT AND ENGINEERING CORP.
LOS ANGELES, CALIFORNIA

NUMBER ESP-5
SUPPL'T - -
PAGE 1 OF 1
ISSUE B
DATE 10-11-43
SUPERSEDES Issue A dated 6/1/43

SUBJECT: DRAWING RELEASE (Accessories)

EFFECTIVE DATE 10/11/43

DIVISION AFFECTED: El Segundo

1. General -

1a. Drawings completed by the Accessories Engineering Department will be forwarded to the Release Group with a "Release Request" marked either "Experimental" or "Production" in the space provided for indicating the kind of release desired. This Release Request will also serve as a "Job Ticket", by placing the job number in the upper, right corner; and obtaining the Project Engineer's signature in the lower margin as authority for release.

1b. Accessories Engineering Department releases will be handled on the basis that all necessary checking has been accomplished prior to release, and will be printed and distributed without passing through the regular engineering release procedure.

2. Experimental Release -

2a. All prints on an Experimental release will be stamped both "ACCESSORIES" and "EXPERIMENTAL", in addition to other stamping, and will be red-line prints.

2b. The Experimental Department will notify the Engineering Department by "Change Requests" of all changes necessary to correct the experimental drawings for production. Upon these changes being incorporated, the tracings shall be forwarded to the Release Group for a "production" release.

3. Production Release -

3a. All Production prints shall be blue-line, and be stamped both "ACCESSORIES" and "OK FOR PRODUCTION", in addition to other stamping.

3b. Experimental drawings re-released without design change for production shall be assigned the next change letter for record purposes. A notice of change is not necessary, and "REL'D FOR PROD - NO CHANGE" shall be entered in the alternate block.

4. Release Quantities and Destinations - The following quantities of prints shall be forwarded to the listed destinations on each release of a drawing:

Destinations and Basic Issue Nos.

Kind of Release	Access. Plann. (03)	Access. Plann. (05)	Engr. File (04)	Vault Copy (502)	Total
Experimental	—	4	1	1	6
Production	12	—	2	1	15

All prints will bear issue numbers, and be forwarded to their destination with a Shipping Notice in duplicate.

James E. Thompson
Assistant to Vice President

ø Revised: 10/11/43

FORM 266-WD 3M 8-43

FIG. 6:2.—Engineering procedures manual.

rules relating to operation of the engineering department. Whenever a question arises regarding the proper mechanics for a certain operation, it is necessary for the person responsible for a decision only to refer to the procedures manual.

It might appear upon superficial inspection that a procedures manual would be required only in large engineering departments and that small departments could depend upon the chief engineer or chief draftsman to define verbally departmental policies, rules, and procedures whenever the need arose. This is not considered desirable as conflicting decisions may be given when long periods elapse between recurrences of similar questions. Also, too much of the executive's time may be consumed in conveying instructions on routine matters. The time spent in explaining a particular policy or procedure *once* is little greater than that required to prepare the information as a written procedure—which can then be made available to all concerned to answer the particular question permanently.

If a provision of an engineering procedure is found undesirable or in error, a revision to correct the fault should be promptly issued. The purpose of a procedures manual is to assist, rather than hinder, departmental operations, and the manual should never become an inflexible book of rules. When a particular procedure is revised, it is necessary to make certain that corresponding revisions are made in all related procedures and that copies of the revised procedures are promptly furnished all manual holders. The original issue of a procedure can be identified as "issue *A*" and its revisions by change letters beginning with "issue *B*" as the first alteration.

Verbal deviations from a procedure should not be permitted as this will lead to the entire procedures system falling into disrepute. In cases where immediate change or correction of a procedure is imperative, an amendment stating the nature of the revision should be issued to all manual holders. A revised procedure incorporating the amendment should be prepared and distributed as soon as practicable.

Procedures are issued to establish the methods and policies considered best for the interest of the engineering department and its employees. Hence, it is necessary for all procedures to be faithfully observed. Each executive and supervisor furnished a procedures manual should be held responsible for his employees following all procedures relating to the activities under his direction.

Procedures manuals are not normally distributed to individual draftsmen. A great deal of information relating to the mechanics of operating the engineering department is contained in the procedures, and therefore it is sometimes difficult to locate immediately the essential information relating to the draftsman's work. A portion of the drafting-room manual should be devoted to a brief explanation of those portions of the procedures that directly affect the work of the individual draftsman. These are largely concerned with proper usage of forms relating to drawing preparation, release, and revision.

SECTION I-3-2 AIRCRAFT DRAFTING ROOM MANUAL

sequence, and this number placed in the LH column of the dash-number block. Refer to the specimen drawing on DRM page I-3-4 for examples.

NOTE: When a dash-numbered part is used only on the right-hand (-1) form of the assembly, the [R] symbol shown on DRM page I-3-4 must be used to identify the part, except that when a Bill of Materials accompanies the drawing, it is possible to indicate the parts for each "hand" of the assembly by the requirements listings in the Bill of Materials. Refer to DRM page I-11-6.

DASH NUMBERS FOR SUB-ASSEMBLIES

12. The general description of the dash numbering system given herein includes the use of dash numbered sub-assemblies, in view of this procedure being extensively used in the past. However, this practice sometimes causes confusion in the planning and manufacturing departments, and is no longer considered desirable. Drawings should not use dash numbered sub-assemblies, and only detail parts should be dash numbered. The information given in paras 11 thru 13, following, is for reference only, and should not be applied to new drawings.

13. Continuing with the procedure outlines in para 11, preceding, dash numbers may be used to identify sub-assemblies of main assemblies. For example: Assume that the part shown in the drawing at DRM page I-3-4 is detailed and dimensioned in place on drawing R09000 - one of the next assemblies of this part. In this case it might be called out as:

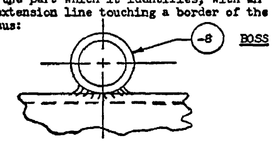
-10 BRACKET ASSEMBLY
CONSISTS OF -2, -3, -4, -6 and -8.

14. The pieces making up -10, namely -2, -3, -4, -6 and -8, would be shown in the usual manner, and -10 would be called out in the dash number block as simply "-10 BRACKET ASSEMBLY." Inspection of the note under -10 on the drawing would identify the pieces making up this assembly.

15. Thus a single basic drawing number, and a single drawing may serve for a large number of parts. The basic number and -1 indicate the LH and RH opposite forms of the basic assembly, additional dash numbers indicate sub-assemblies, and other dash numbers identify the pieces forming the sub-assemblies.

LOCATION OF DASH NUMBERS

16. On all drawings (except tabulated) each dash number should be placed within a 3/8 circle close to the part which it identifies, with an arrowed extension line touching a border of the part. Thus:



17. It is always necessary to assign a title to dash numbers, except reference dash numbers. In most cases the basic noun is sufficient.

18. The requirements for dash numbered parts should not be called out on the face of the drawing, but only in the dash-number block or Bill of Materials.

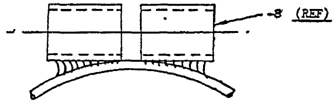
USING DASH NUMBER PARTS ON OTHER DRAWINGS

19. Only tabulated dash numbered parts may be called out on drawings other than their own basic drawing, except for reference purposes.

20. When the dash number is shown for reference on another drawing, this must be indicated in the conventional manner, and title and requirements are omitted. Thus: "B07800-4(REF)"

DASH NUMBERS CALLED FOR MORE THAN ONCE ON A DRAWING

21. Whenever it is necessary to call for a certain dash number in more than one place on a drawing, the supplementary dash-number should be referenced, thus:



the circle omitted, and the requirements totaled in the dash number block or Bill of Materials. Never circle a given dash number more than once on a drawing.

CANCELLED DASH NUMBERS

22. A dash number once cancelled should never be used again. The next dash number in sequence shall be assigned to a new dash numbered part. This rule is necessary to avoid errors in manufacturing and stocking of parts.

23. When a dash number is cancelled, the requirements and material description are removed from the dash number block, and "X" placed through these spaces - but the dash number itself remains in the block to indicate that the particular number has been cancelled. Thus:

R.H. DASH NO.	L.H DASH NO.	NO. REQ.	SIZE (MATERIAL)	DESCRIPTION (MATERIAL)	ARMY (MATERIAL SPECIFICATION)	NAVY (MATERIAL SPECIFICATION)	COMM. (MATERIAL SPECIFICATION)	
	-6	2	1 3/4 S L.	5/8 OD x .035 C.M STEEL TUBE		AN-WW-T-850 COND A	4130	2
	-4							
	-2	1	3/4 S L.	1/2 OD x .035 C.M STEEL TUBE		AN-WW-T-850 COND A	4130	2

LIMITS ON DIMENSIONS UNLESS OTHERWISE SPECIFIED | NAVY | ARMY

REVISED: 1/1/44

INTERSTATE
Aircraft and Engineering Corporation

FIG. 6:3.—Drafting-room manual.

DRAFTING-ROOM MANUAL

The function of a drafting-room manual (DRM) is the establishment of definite drafting practices for the preparation of engineering drawings applicable to a given company and the furnishing of the detail design-reference data frequently required by the draftsmen during prepara-

tion of layout and manufacturing drawings. An explanation of the general operation of drafting-room procedures should also be included. The DRM should not give instructions on *how* to prepare a drawing, for it

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MATERIAL	SPEC	USES AND REMARKS
Brass Bar, Rod, Shapes	FED-QQ-B-611(E)	For bushings where loads are light and good wearing qualities are not required. Refer to spec for Compositions and Tempers.
Bar and Rod (Rolled Brass)	AN-QQ-B-646	For Turnbuckle Barrels
Castings-Red Brass	Refer to "Bronze Castings"	
Naval Brass (Tobin Bronze)	FED-QQ-B-636 (E) Type I - Rod - Soft, 1/2H, H Type II - Bar - Soft, 1/2H, H Type III - Shapes - Soft Only Type IV - Plate - Soft, 1/2H Type V - Sheet - Soft, 1/2H Type VI - Strip - Soft, 1/2H	Specify "Soft", "Half Hard" or "Hard".
Sheet, Plate and Strip	FED-QQ-B-611 (E)	For name plates, tags, bonding strips, etc. Refer to spec for Compositions and Tempers.
Tubing, Seamless	NAVY-44T15	Refer to spec for suitable grades & types/

BRASS, BRONZE, COPPER

Interstate Aircraft & Engr. Corp. Material & Process Spec

FIG. 6:4.—Material specification and usage index.

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MATERIAL	SPEC	USES AND REMARKS
Heat-Treatment Process for Aluminum Alloys	AN-QQ-H-186	
Heat-Treatment Process for Steels (Aircraft)	AN-QQ-H-201	For types of hardening other than carburizing and nitriding. Specify tensile strength.
Insignia for Aircraft (Nat'l Star)	AN-I-9	Intended for use as a means of identification. Do not specify.
Marking for Aircraft and Airplane Parts	USA-98-24105	Do not specify on drawings.
Magnetic Inspection - General Spec for Process and Application (Magnaflux)	AN-QQ-M-181	Specify for all highly-stressed welded and machined steel parts and HT steel parts, as required by Stress Group, or as specified in Interstate Inspector's Manual.
Metals - Radiographic Inspection-Process & Application (X-Ray)	AN-QQ-M-188	Specify for all Class A castings.
Pipe Threads - Taper Aircraft	AN-GGG-P-363	Specify on all drawings requiring pipe threads.

PROCESSES

Interstate Aircraft & Engr. Corp. Material and Process Spec

FIG. 6:5.—Process specification and application index.

can be safely assumed that the user has mastered the principles of translating a three-dimensional object into a two-dimensional projection through the medium of pencil, drafting instruments, and paper. Instead, definite information on *what* is to be drawn should be given.

The scope of a DRM should be broadened beyond drafting practices and procedures to include a brief but comprehensive survey of the materials and processes used in manufacturing the company's products. Thus, the draftsman not only will be provided with the requirements for executing the drawing "picture" but is also given an insight into manufacturing processes. This information will assist in insuring that parts are intelligently designed for production.

An important portion of the DRM is an index of company standard materials and processes, similar to the specimen pages shown in Figs. 6:4 and 6:5. These list all materials and processes approved for use on company drawings and eliminate the need for draftsmen to spend time in determining the proper material or process for a given application. Their use also minimizes the variety of materials employed, with consequent reductions in purchasing expense and raw-stock inventories.

The variety of information that can be placed in a DRM is almost limitless, but it should be confined to information that the draftsman will frequently require. The following outline provides an indication of the subjects for a DRM suitable for a majority of engineering departments engaged in product design:

Chapter 1. Drafting Practices
General arrangement of drawings. Standard method of drawing. Drafting conventions. Manufacturing notes. Material specifications. Process specifications. Quantity required and next assembly. Naming of drawings. Tabulated drawings. Applied descriptive geometry.

Chapter 2. Engineering Department Organization and Procedures
Organization of the engineering department. Numbering of drawings. Methods and procedures. Drawing changes. Standard parts and designs.

Chapter 3. Materials [1]
Weights of materials. Aluminum and its alloys. Steels. Nickel alloys. Miscellaneous alloys. Plastics. Rubber products. Fabrics. Index of material specifications. Standard raw-stock sizes.

Chapter 4. Processes [1]
Forming of metal parts. Soldering, brazing, and welding. Heat-treating. Corrosion prevention. Miscellaneous processes. Index of process specifications.

Chapter 5. Finishes
Finish notation on drawings. Index of finish specifications.

Chapter 6. Design Data [1]
Rivet and bolt data. Limits, tolerances, and clearances. Bend allowances. Spring design. Casting and forging design. Keyway design.

[1] The data shown for Chap. 3, 4, and 6 (except the specification indices) should be in the design handbook when this publication exists.

It will be observed that much of the material contained in the DRM can be found in various reference books and manuals. Compilation of reference material required by the draftsman in his daily work on company products eliminates the necessity for each draftsman to obtain a variety of reference books. Furthermore, it insures that all draftsmen will be in possession of the most frequently used data, without having to search through a variety of books or consume the time of other draftsmen by requesting assistance in locating basic reference data.

ELEMENTS OF A DRAFTING SYSTEM

The essential requirements for manufacturing drawings are that complete information for fabricating the article be clearly shown and that the parts specified are so arranged and identified that spare parts can be ordered and stocked. A complete set of drawings for an article should include a final-assembly drawing, drawings of all necessary subassemblies, and detail drawings for individual parts. All detail drawings should completely disclose and illustrate the construction of the part and supply all dimensions and other information necessary for its manufacture. The division of the article into subassemblies should be in accordance with a practicable manufacturing assembly procedure. Schematic wiring, plumbing, and control-mechanism diagrams, when necessary for maintenance of the article, should be included in the set of drawings.

In Figs. 6:6 through 6:9 [1] are shown a group of related detail, subassembly, and assembly drawings that illustrate the nature and sequence of drawings required to provide manufacturing information. Figure 6:6 describes a detail wood member that is combined with other wood members and spacers to form the longeron subassembly shown in Fig. 6:7. Figure 6:8 shows manufacturing information for a welded steel fitting,

[1] Figures 6:6 through 6:9 show drawings using separate bills of material (see Chap. 8). These are not shown and contain materials data and requirements for the drawings.

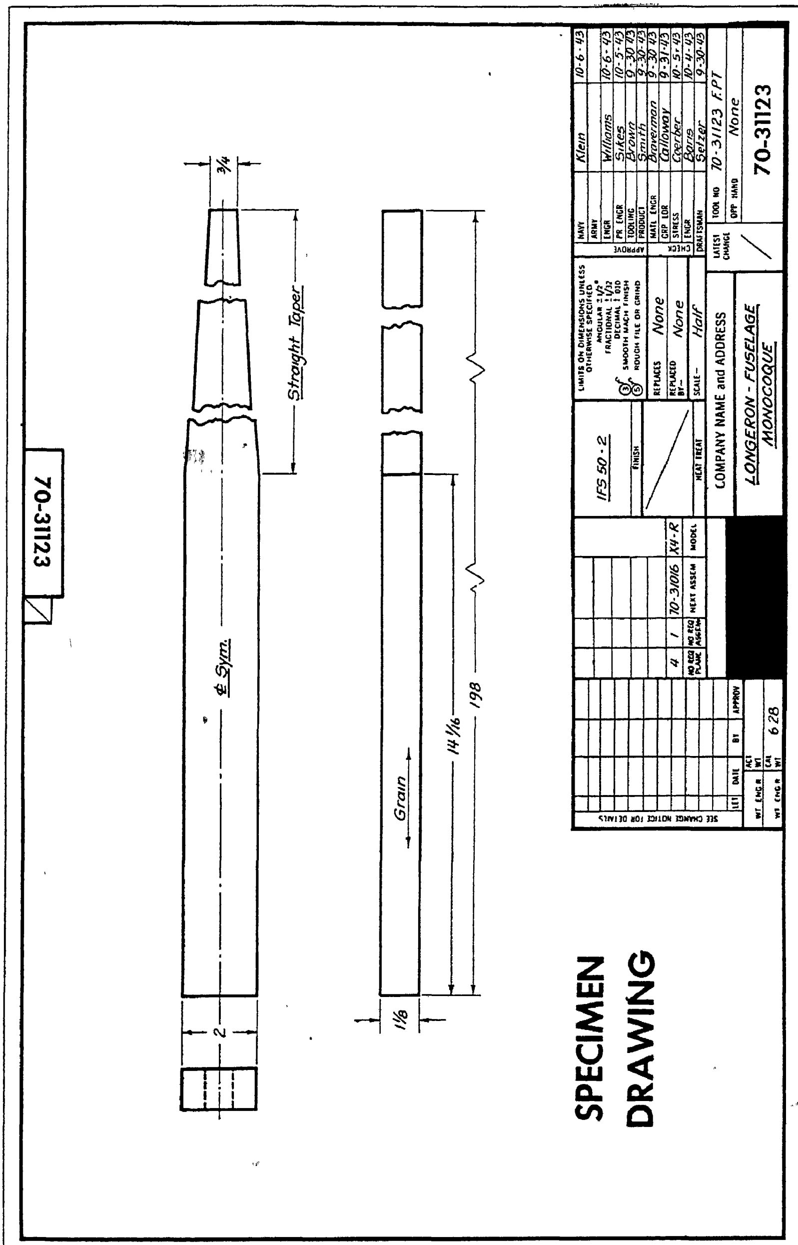


FIG. 6:6.—Wood-detail part drawing.

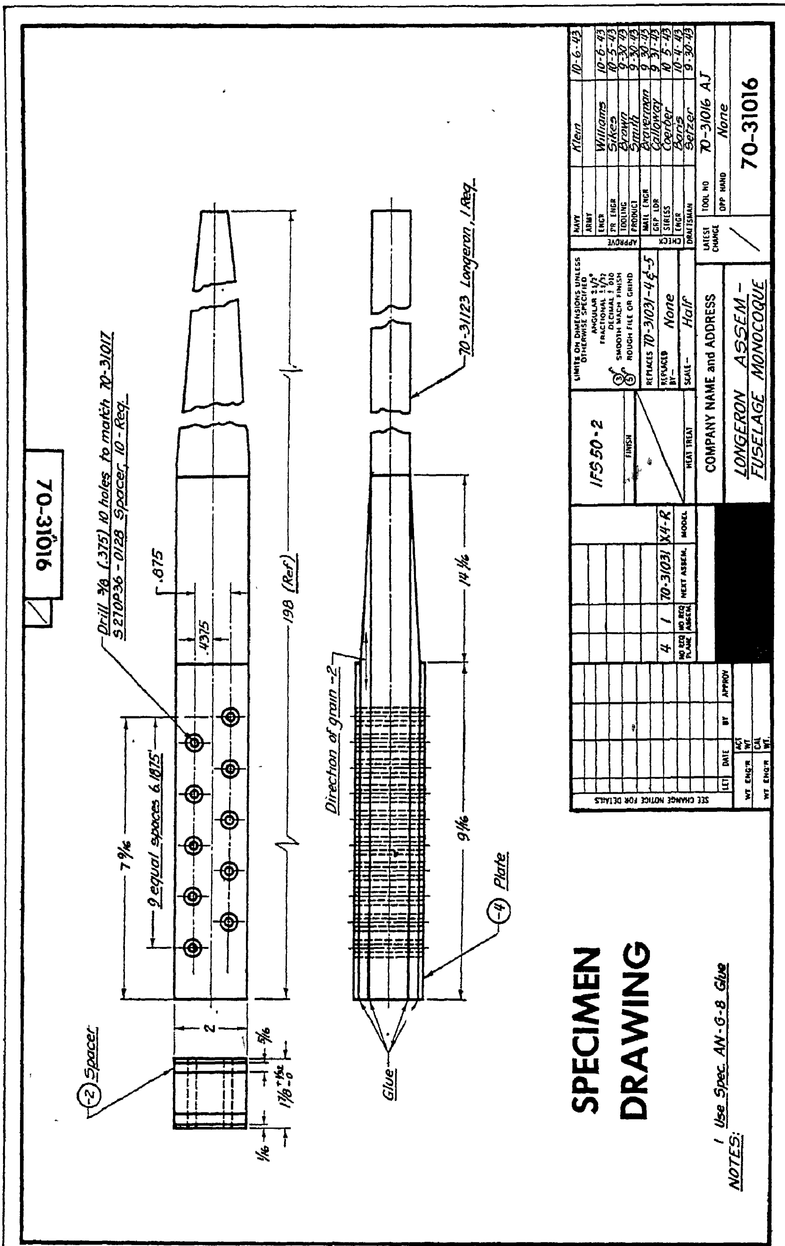


FIG. 6:7.—Wood subassembly drawing.

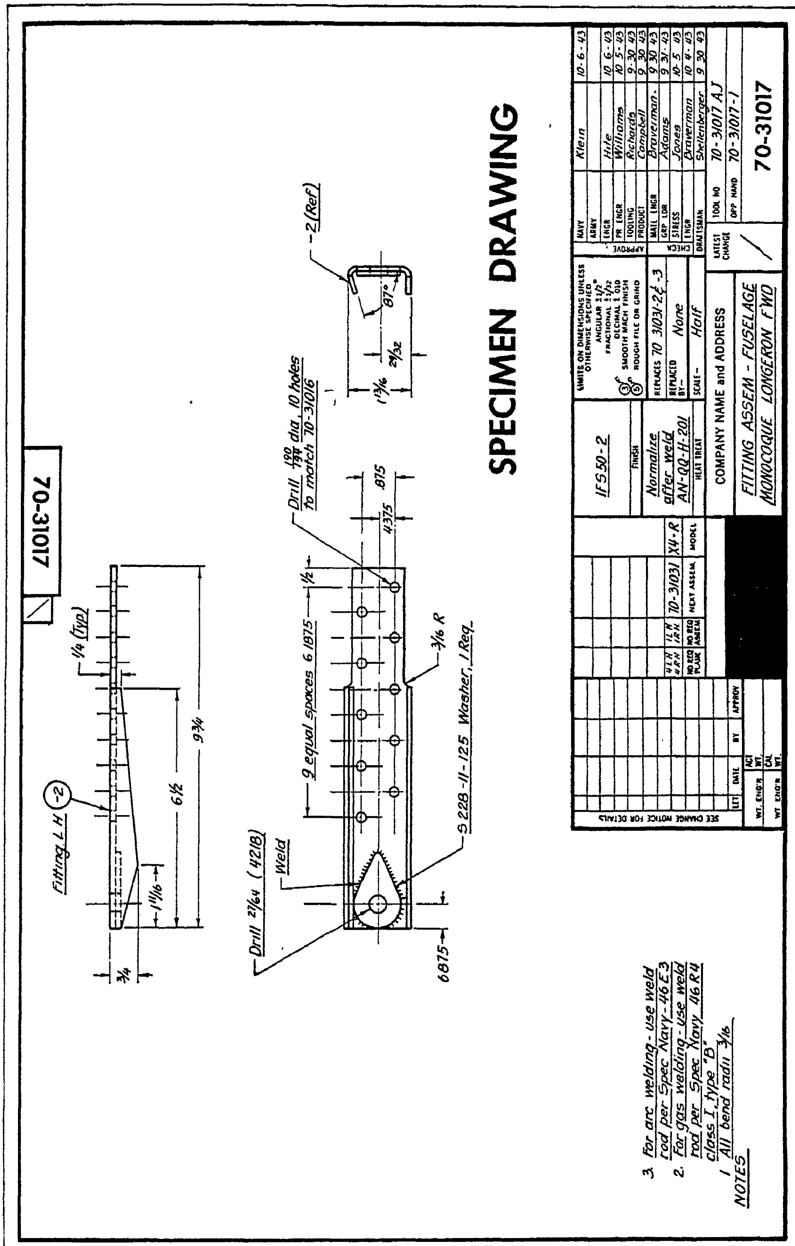


FIG. 6:8.—Steel subassembly drawing.

which is combined with the longeron subassembly to form the longeron-and-fitting assembly shown in Fig. 6:9. To carry this series on to the final assembly drawing would require a fuselage assembly drawing,

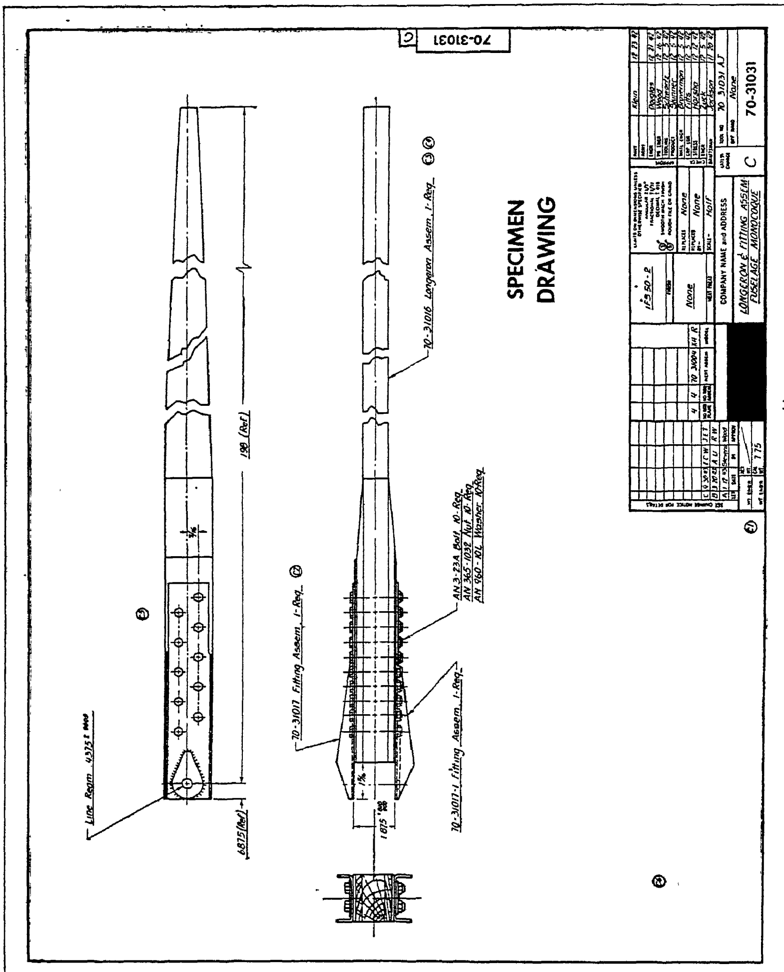


Fig. 6:9.—Assembly drawing for parts shown in Figs. 6:7 and 6:8.

showing the assembly of four longeron-and-fitting assemblies with various associated parts to form the fuselage structure, and a final assembly drawing of the complete airplane—calling out the fuselage assembly with the additional major assemblies and installations required to assemble the complete airplane.

Whenever large, complicated products are involved, need arises for

installation drawings similar to the example shown in Fig. 6:10. These provide means of specifying parts required to install major components during final assembly of the structure and give instructions regarding

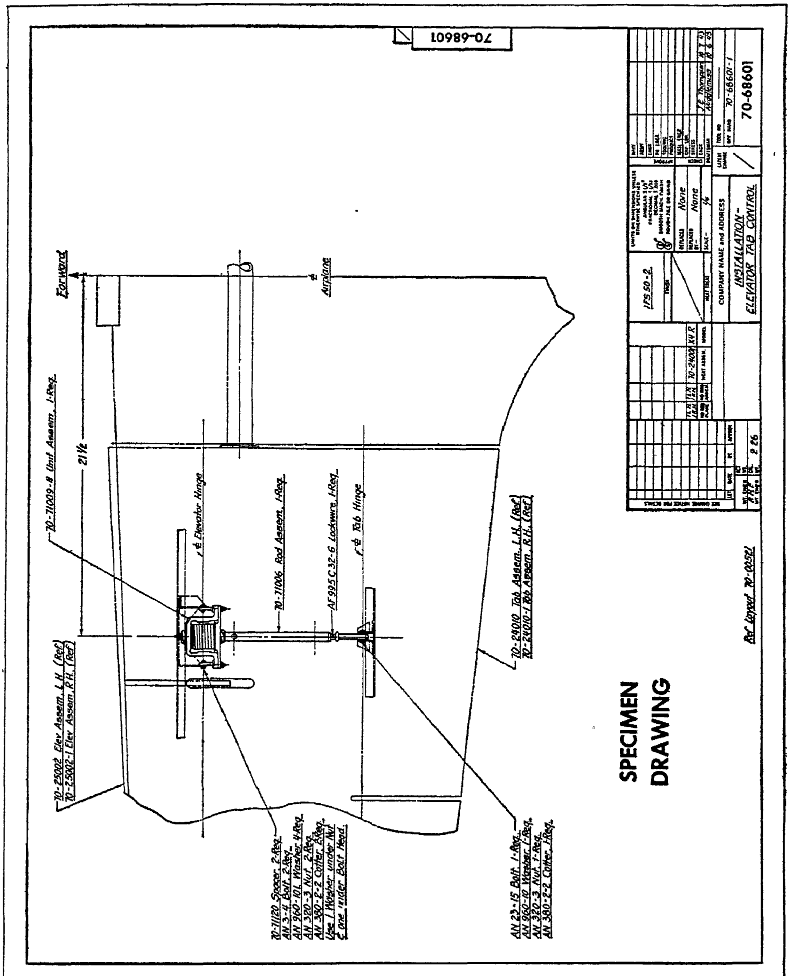


Fig. 6:10.—Installation drawing for elevator-tab actuating unit.

the proper method of installation. In the absence of installation drawings it would be necessary to specify a multitude of attaching parts on the final assembly drawing. This not only would confuse this drawing but would also deviate from the basic rule requiring an arrangement of drawings that agrees with manufacturing and assembly procedure.

Installation drawings provide a means of specifying attaching parts

and installation instructions at the proper places in the sequence of assembly. Each installation drawing should specify the parts to be installed and the bolts, washers, nuts, screws, clips, cotters, and other

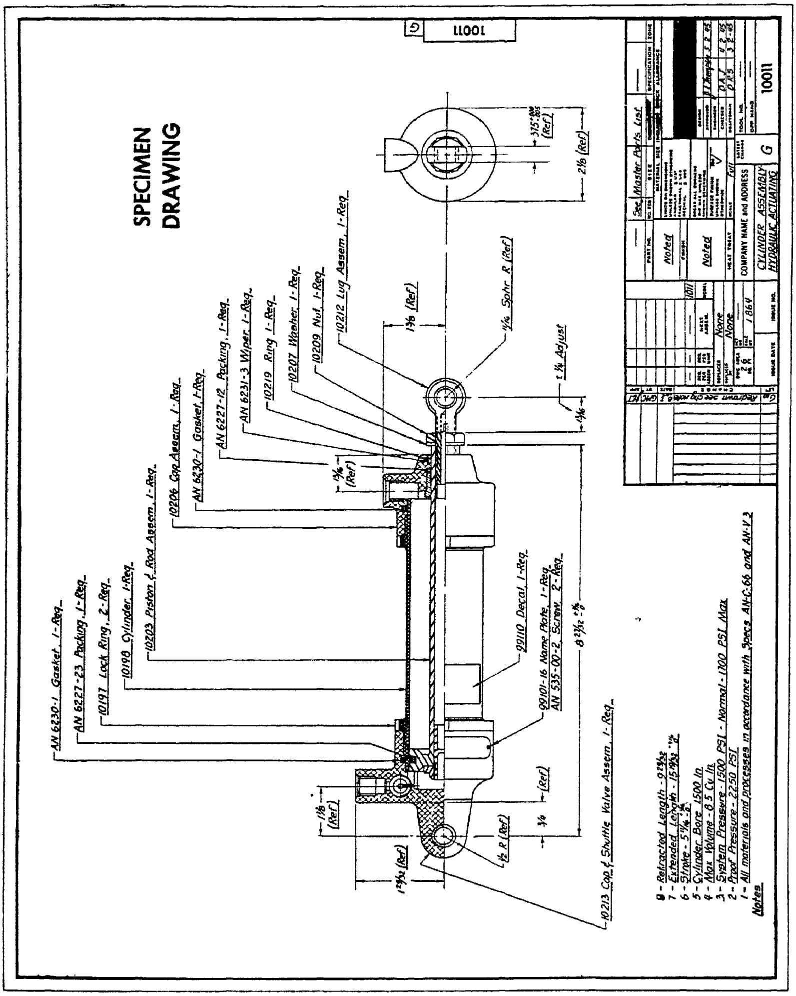


FIG. 6:11.—Final assembly drawing of hydraulic actuating cylinder.

attaching parts necessary to complete the installation. Structure and other units to which the installation parts attach should be shown in phantom outline and when identified at all should be clearly designated "reference" parts.

The final assembly drawing for a hydraulic actuating cylinder is shown in Fig. 6:11. This is a comparatively small article and does not

require installation drawings. All subassemblies and detail parts required to complete the final assembly are specified on the final assembly drawing.

Standard Method of Drawing

When an installation or assembly drawing for a vehicle requires a side view of the vehicle or part of it, it is customary to prepare the

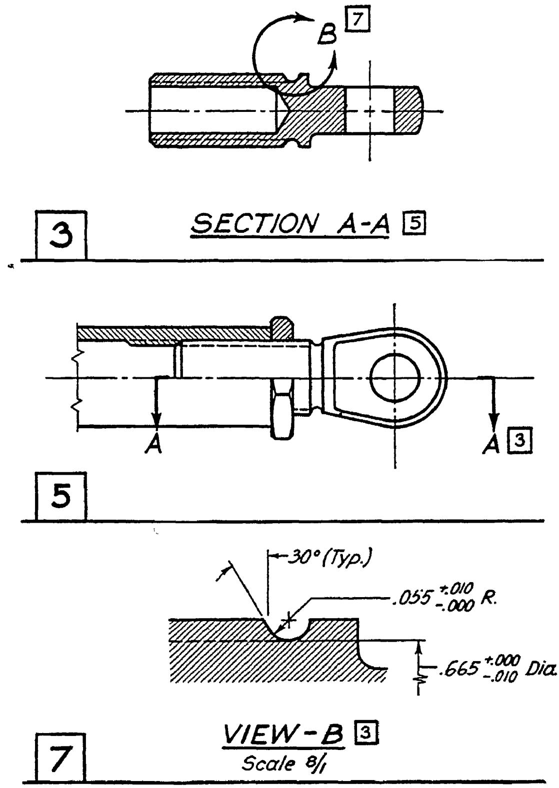


Fig. 6:12.—Section and detail views.

drawing as viewed from the left side of the vehicle headed toward the left. All related subassemblies and details should be drawn in the position that they assume in the installation or assembly drawing. All subassembly and detail drawings not forming part of the set of drawings that describes a vehicle should show the part in the position that it occupies in the final assembly drawing, not inverted or reversed to agree with a position that it may assume in a jig or machine tool during manufacture.

Installation and assembly drawings having both left and right sides symmetrical and identical may be drawn showing the left side *only* and with the notation *CL SYM* placed across the drawing centerline. The drawing should be arranged from the viewpoint of an observer standing either at the front or rear of the article and looking along its length. The fore-and-aft direction of the drawing should be clearly indicated by an arrowed extension of the longitudinal centerline and suitable notation.

Drawings should be made by the system of orthographic projection known as "third angle" or "third quadrant" and show top, front, and side views of the object. Very simple shapes, such as pins or bolts, may omit the top view, which would be a duplication of the front view. Perspective or isometric drawings can sometimes be used to advantage in illustrating a complex installation. Auxiliary projections and section and detail views (see Fig. 6:12) to show the true dimensions and form of a part or portion thereof should be used as required. In general, sufficient views to describe the part clearly for manufacturing purposes should be shown, and no more. However, it is rarely acceptable to show less than two views of the object.

Simplification of Drafting

Drafting that serves only to enhance the appearance of a drawing should be eliminated, and all engineering effort concentrated on rapidly preparing accurate, understandable drawings. The following drafting simplifications are recommended as logical means of eliminating unnecessary engineering expense:

a. Do not specify rivet lengths, but arrange with the factory to select the correct length to produce the proper rivet-head size.

b. It is unnecessary to show all the rivets or bolts in a row or group. Show one at each end of a row or one of a group. Centerlines and notation of the total quantity are sufficient for the remainder.

c. Do not show cotter pins or lock wire. These can be installed where required as shop practice and checked by the inspection department. However, they must be specified on the drawing.

d. Show hidden outlines only where absolutely necessary for clarity.

e. It is not necessary to crosshatch sections to identify material. Opposite-direction hatching should be used for clarity wherever a junction of materials occur.

f. Crosshatching may be eliminated on any section that is understandable without hatching.

g. Do not show details of parts such as name plates, that are detailed upon another drawing.

h. Details of instrument faces and other purchased equipment need not be shown.

i. It is not necessary to show more of reference or phantom parts than is required to locate the area concerned.

j. Only those views necessary to describe the part clearly for manufacture should be shown.

k. It is not necessary to show welding symbols on the next assembly of a welded part—only on the drawing actually used to manufacture the welded assembly.

These are only a few general drafting simplifications that can be utilized without sacrificing the drawing's utility. Many more that apply with special emphasis to the products of a particular company can be discovered without difficulty. Each will serve to reduce the total engineering expense.

Dash Numbers

Dash numbers of the basic drawing number can be used to reduce drafting expense as they avoid the preparation of a separate drawing for each part, assembly, and installation. The use of "—1" as a suffix to the basic drawing number (see Chap. 7) to indicate the right-hand opposite form of a detail part, assembly, or installation often halves the quantity of drawings required. Furthermore, it is often possible to dimension and describe completely all or many of the detail parts of an assembly in their proper place on the assembly drawing. Each detail part can then be assigned a dash number of the basic drawing number for manufacturing and stock identification.

When two or more pieces are riveted, welded, or otherwise permanently joined to form a part that is removable as a unit, each piece must be assigned a part number by which it can be manufactured and stocked. Dash numbers can be used for this purpose, and separate detail drawings eliminated. Dash numbers can also be used to identify individual pieces that are removable as a unit from the assembly.

The use of dash numbers may be classified under four general headings:

a. To designate the left- and right-hand opposite forms of a detail, assembly, or installation (see Chap. 7).

b. To identify a detail part of an assembly that can be sufficiently detailed and dimensioned in its proper place on the assembly drawing.

c. To indicate subassemblies of a main assembly.

d. To tabulate two or more similar parts described by a single drawing (see Tabulated Drawings later in this chapter).

Use of dash numbers for part identification is advisable for experimental drawings and for production drawings when only a small quantity of the article will be produced. Their use saves considerable engineering expense but limits the flexibility of the drawings. It is difficult to call for a dash-number part on a drawing other than its own, and changes in a very small part may require revision and reissuance of a large roll-size tracing. Furthermore, inexperienced factory personnel sometimes have difficulty in understanding a dash-number system of parts identification. For these reasons it is recommended that individual drawings be prepared for every part when large production quantities are involved.

Dash Numbers for Detail Parts of an Assembly

Inasmuch as "—1" is used to identify right-hand opposite parts, the dash-number detail parts should begin with "—2." The even dash numbers (such as —2, —4, —6, etc.) should be used for left-hand detail parts, and the odd dash numbers (—3, —5, —7, etc.) for the right-hand opposite detail parts. It is always understood that —3 is the right-hand opposite of —2, —5 the right-hand of —4, etc. When a detail part is not left- and right-hand, it should be assigned the next *even* dash number in sequence, and its complementary odd dash number remains unused. This maintains the basic significance of dash numbers in all cases.

On all drawings (except tabulated) each dash number should be placed within a 3/8-in. circle close to the part that it identifies, with an arrowed extension line touching a border of the part (see Fig. 6:13). It is always necessary to assign a title to dash numbers, except those called out solely for reference. In most cases the basic noun is sufficient. The requirements for dash-numbered parts should not be called out on the face of the drawing but only in the bill of material. Unless this procedure is followed, errors might result from drawing changes in which dash-number requirements may be changed in one location and a corresponding change overlooked in another area.

Whenever it is necessary to call for a certain dash number in more than one place on a drawing, the supplementary dash number should be referenced and the 3/8-in. circle omitted. Thus: "—8 (Ref)." The requirements will be totaled in the bill of material.

Only tabulated dash-numbered parts should be called out on drawings other than their own basic drawing, except for reference purposes. When additional uses are found for a dash-numbered part, it should be separately detailed under a basic drawing number and the dash-number

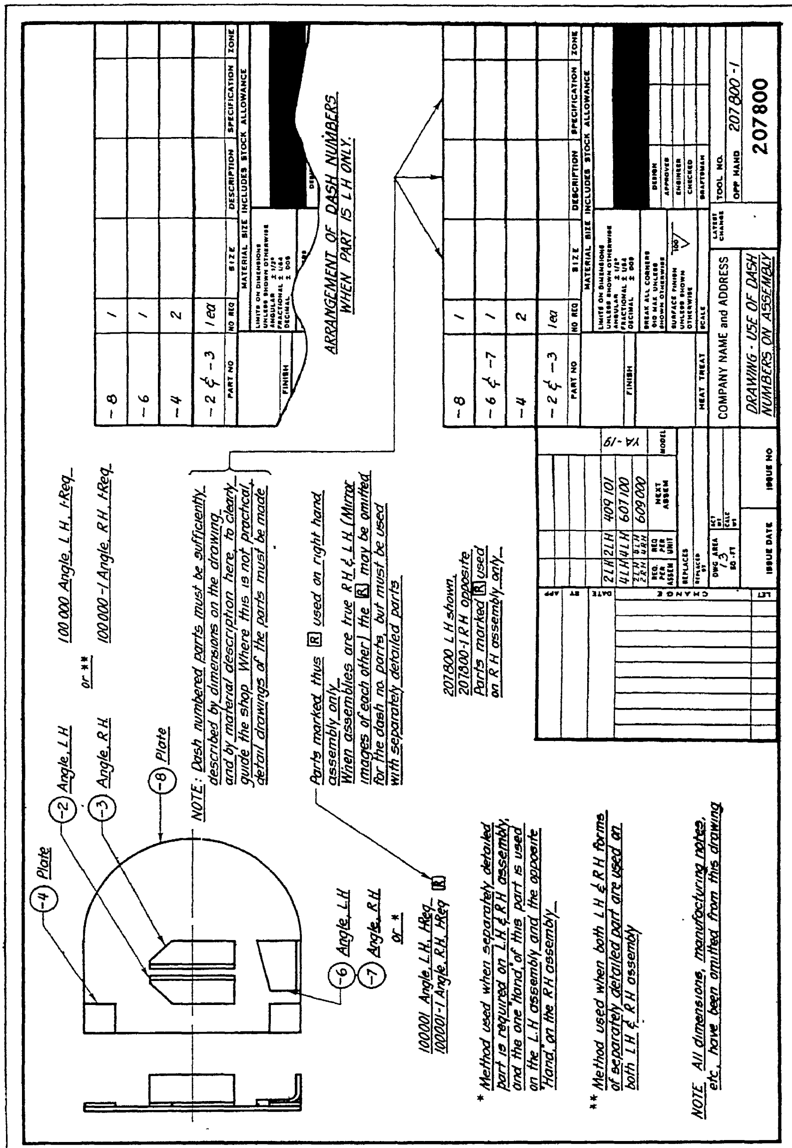


FIG. 6:13.—Use of dash numbers on assembly drawing.

designation canceled. This is necessary because the dash-number identification does not provide for a multiplicity of next assemblies and the listing of quantities required per model. When a dash number is shown for reference on another drawing, this should be indicated in the conventional manner, but the title and requirements may be omitted. Thus: "207800-4 (Ref)."

Dash Numbers for Subassemblies

Some engineering departments have extended the use of dash numbering to identify subassemblies of an assembly drawing. However, this practice sometimes causes confusion in the manufacturing departments and is not considered desirable. The best over-all economy will be obtained by confining the use of dash numbers to detail parts and preparing separate drawings for subassemblies. The use of dash numbers for subassemblies is described here for information but is not recommended.

To continue with the procedure outlined on page 110, dash numbers may be used to identify subassemblies of main assemblies. Assume that the part shown in the drawing of Fig. 6:13 is detailed and dimensioned in place on drawing 609000—one of the next assemblies of this part. In this case it might be called out as

—10 BRACKET ASSEMBLY
CONSISTS OF —2, —3,
—4, —6, AND —8

The pieces making up —10 (namely, —2, —3, —4, —6, and —8) would be shown in the usual manner, and —10 would be called out in the bill of material as simply "—10 Bracket Assembly." Inspection of the note under —10 on the drawing would identify the pieces making up this assembly.

Thus a single basic drawing number and a single basic drawing may serve for a large variety of parts. The basic number and —1 can indicate the left- and right-hand opposite forms of the major assembly; additional dash numbers identify subassemblies; and other dash numbers indicate the pieces forming each subassembly.

Canceled Dash Numbers

A canceled dash number should never be used again. The next dash number in sequence should be assigned to a new dash-numbered part. This practice is necessary to avoid errors in manufacture and stocking

of parts. When a dash number is canceled, its requirements and description are removed from the bill of material and an *X* placed through these spaces—but the dash number itself remains to indicate that the particular number has been canceled.

Tabulated Drawings

Groups of similar parts, which vary only in a few particulars and are basically the same—such as name plates for closely related articles, bolts of different lengths, and bushings of various diameters—may be tabulated on one drawing to reduce drafting expense. A drawing is prepared to show the part to be tabulated (see Fig. 6:14), and the variable data is identified by letters keyed to values given in the tabulation block. Dash numbers of the basic drawing number identify each size or arrangement of the part.

The basic number of a tabulated drawing serves only to identify the drawing and should not be used as a part number. Drawing tabulations should begin with —2, (reserving usage of —1 to identify the right-hand opposite form of a complete part or assembly) and continue in accordance with the rules established on page 110. Drawings involving dimensional tabulation normally use the letters *L*, *W*, *T*, and *G* to indicate length, width, thickness, and grip. Letters *A*, *B*, and *C* are used for other variables.

All tabulated drawings should show the "number required," "model," and "next assembly" drawing number for each part or assembly listed in the tabulation. This is the prime difference between tabulated drawings and the standard-part drawings shown later in this chapter. Standard-part drawings do not show model requirements, for it is assumed that these parts are universally usable on a majority of company products, whereas tabulated drawings are confined to usage on a single model or small group of related models.

Coded Drawings

Cases often arise where an installation or major assembly for an existing production model can be used on a new model with some substitution of parts affecting only a *small* portion of the total drawing. In such a case it is possible to code the installation or assembly drawing to serve for both models, with elimination of considerable drafting time.

The existing drawing number is assigned a —500 dash-number suffix to establish a new drawing number for the modified installation or assembly required for the new model, and the variable parts (both old and

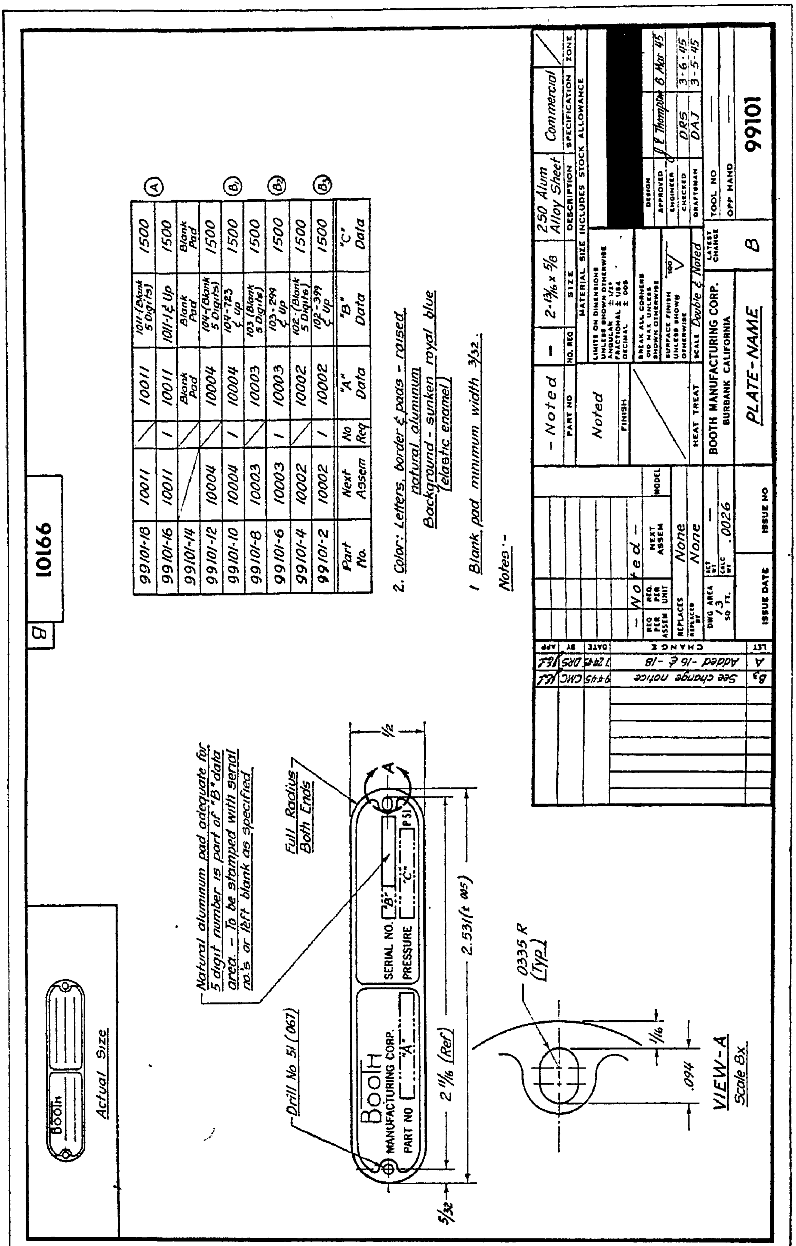


FIG. 6:14.—Tabulated name-plate drawing. Model designations are same as next assembly numbers in this case and are not listed.

SYMBOLS FOR CODED DRAWINGS

(*a*) *Where the installation* (or assembly) *is not L. H. or R. H.*

PARTS MARKED THUS: ⊙ USED ON 00000 (basic no.) ONLY

PARTS MARKED THUS: ⊗ USED ON 00000–500 ONLY

PARTS MARKED THUS: ⊕ USED ON 00000–502 ONLY

ALL OTHER PARTS USED ON ALL INSTALLATIONS (or assemblies) CALLED FOR HERE.

(*b*) Where the installation or assembly is *both L. H. and R. H.*, the drawing *should not be tabulated for more than two steps*, and the following notation used:

PARTS MARKED THUS: ⊙ USED ON 00000 (basic L.H.) ONLY

PARTS MARKED THUS: ◑ USED ON 00000–1 (basic R.H.) ONLY

PARTS MARKED THUS: ⊗ USED ON 00000–500 (coded L.H.) ONLY

PARTS MARKED THUS: ⦶ USED ON 00000–501 (coded R.H.) ONLY

ALL OTHER PARTS USED ON ALL INSTALLATIONS (or assemblies) CALLED FOR HERE.

TABULATION BLOCK FOR CODED DRAWINGS

A tabulation block to cover the model requirements and next assemblies must be placed on the drawing, about 4 inches to the left of the title block, similar to the following example:

501234-502	2	4	509876	YA-19
501234-500	2	4	506789-500	1-GB
501234	2	4	506789	1-GT
PART NUMBER	REQ. PER ASSEM.	REQ. PER UNIT	NEXT ASSEM.	MODEL

FIG. 6:15.—Notations for coded drawing.

new) are coded. A maximum of three models can be covered by this method when the variations in each are *minor*. The basic drawing number (which remains unchanged in the drawing title block) identifies the original model; —500 is used for the first variation, and —502 for the second variation. It is not practical to carry the coding procedure beyond three models as the drawing usually becomes too confusing to justify the saving in drafting expense. Drawings involving left- and right-hand opposite forms should not be coded for more than two models. In such cases new drawings, assigned new numbers, should be made to cover additional models. These should carry a similarity note (thus: "Similar to 670961") to aid in coordinating tooling and manufacturing planning.

When a drawing is coded, it is necessary to use coding symbols in order to distinguish the new parts from the old ones and guide the manufacturing departments in selecting the correct parts to form the proper assembly for each model (see Fig. 6:15). Both old and new parts are called for in the field of the drawing, written one below the other as a dual call-out, with the proper coding symbol following each. A notation is placed upon the drawing, directly to the left of title block to identify the coding symbols. A tabulation block listing model requirements appears adjacent to the coding symbol notation. All model requirements are removed from the title-block space, and the word "Noted" is placed in this area.

A notice of change is prepared for the basic drawing number, showing the reason for change as "Drawing coded for —500 (and/or —501, —502)" and listing all parts added or deleted. The coding procedure must be carried on through next assembly drawings until a point is reached where interchangeability is no longer affected. Usually this point is where a new drawing, under a new drawing number, exists for the new model. In cases where a new drawing is not prepared, it may be necessary to carry the coding procedure on through to the final assembly drawing. Detail and subassembly drawings of the coded drawing do not require addition of the exact next assemblies (—500, —501, etc.) unless also coded or when the quantity required will be different for the new assemblies. Ordinarily, only the basic numbers need be shown in the model-requirements space.

Drawing Titles

The drawing title is the name of the part described by the drawing. It should consist of the simplest basic name for the part, followed by a dash and suitable description. The descriptive terms should be ar-

ranged in an order that names the part as it would be identified in conversation when the title is read in this manner: Begin at the dash, read straight through to the end, and lastly read the basic name preceding the dash. Thus, "Plate-Retracting Screw Guide" is read as "Retracting screw guide plate."

The basic name should not be descriptive of the method of manufacture but must describe the nature or function of the part. Names such as "casting," "forging," "weld assembly" are meaningless to the maintenance man searching through a catalogue to locate parts needed for repairs.

Punctuation in drawing titles should be limited to a single dash, with the exception of periods required for some abbreviations. The basic name should never be abbreviated, but abbreviations are sometimes desirable in the remainder of the title. All abbreviations should conform to the standards for scientific and technical terms established by the American Standards Association.

Basic names of more than one word should be used only in the case of assembly drawings. Names such as "tie rod" and "jackshaft" can be handled in the following manners:

SHAFT—TRANSMISSION JACK
Read as: "Transmission jackshaft"

or

ROD—FRONT AXLE TIE
Read as: "Front axle tie rod"

Basic names of more than one word are necessary in titles for assembly and installation drawings. Thus:

RESERVOIR ASSEMBLY—SHIMMY DAMPER
Read as: "Shimmy damper reservoir assembly"

or

POPPET AND SEAT ASSEMBLY—SELECTOR VALVE
Read as: "Selector valve poppet-and-seat assembly"

The details of an assembly must be assigned titles that agree with the name of the assembly and must be consistent with one another. For example, two subassemblies of an instrument-panel assembly might be designated as "Bracket Assembly—Instrument Panel" and "Support Assembly—Instrument Panel." Both are proper assembly-drawing titles, but the titles assigned to their detail drawings must distinguish between the assemblies. Thus:

GUSSET—INSTRUMENT PANEL <u>BRACKET</u>
PLATE—INSTRUMENT PANEL <u>SUPPORT</u>

Note that the naming of detail parts follows the same choice of words as the assembly.

The words "installation" and "layout" are acceptable as basic drawing names. For instance:

INSTALLATION—TAIL WHEEL

and

LAYOUT—LANDING GEAR WHEELS RETRACTED MECHANICAL WARNING INDICATOR

No two parts (except standard parts or tabulated parts) for a given model should have exactly the same title. When two or more parts are similar or perform the same function, their location or relative position can be used to provide separate identity. Thus:

PLATE—CAMERA MAGAZINE CENTER
PLATE—CAMERA MAGAZINE SIDE
PLATE—CAMERA MAGAZINE COVER

In general, the drawing title should be as simple as possible without inadequately describing the part or failing to distinguish among similar parts.

DESIGN HANDBOOK

An engineering department of moderate size will find a company-design handbook of value. In such a handbook are listed the desired design methods for products manufactured by the company, based upon preferred manufacturing methods and available equipment. Each draftsman and designer is furnished a copy of the design handbook, and all designs that involve deviations from established design methods require approval of the chief development engineer or chief engineer.

A design handbook is not intended to circumscribe creative, functional design but, instead, to direct *production design* into forms that will be possible of economical manufacture. Its purpose is to guide the designer in avoiding designs that will be unnecessarily difficult and expensive to produce. The outline of a design handbook should not be based upon the kind of part designed but rather upon evaluation of the principles, capacities, limitations, and relative economy of the materials, machine tools, and processes used to manufacture company products. A design handbook suitable for a majority of product design can be prepared from the following outline:

Chapter 1. Factors Governing Manufacturing Economy
Chapter 2. Serviceability of Designs
Chapter 3. Lubrication as a Factor in Design

STANDARD PARTS AND DESIGNS

A standard part differs from other parts in that it is not identified with any one particular model but is (or can be) used universally over a range of models. However, a part used on several models does not always merit classification as a standard. To become a standard the part must be one that could conceivably be used on nearly every model. Standard parts should not be confused with tabulated parts.

A standard design establishes a uniform method of accomplishing a certain manufacturing or assembly operation and simplifies drafting by eliminating repetition of elaborate notes on the manufacturing drawings. Examples of one type of standard design are lightening holes, stiffening beads, rivet-installation data, and electrical-cable assembly information. A second type of standard-design drawing is used to show "envelope" dimensions for design components standardized by a recognized industry committee or governmental agency.

During the preliminary design investigation of a new product a careful study should be made of existing commercial industry and government standard parts, and as many as possible used. Hardly a day passes in a large engineering department without at least one special part being designed for an application where an existing standard part will serve just as well. A good example of this is a special bolt for use as an adjustable stop. The fact that such a bolt requires threads for its full length frequently results in the design of a special part, when a square-head setscrew can be used for a majority of such applications. Setscrews are available in a wide variety of diameters and lengths and always have full-length threads. The fact that these setscrews have a

comparatively small head area is not important; for if there is a possibility of misalignment or deflection causing the bolt head to slip past its stop, this can be prevented by using a larger stop rather than a special oversize bolt head. The establishment and use of design standards should also be encouraged, to take advantage of savings in design and drafting time that can be realized through wise application of this practice.

There are four basic classes of standards, designated as

a. Government standards, such as:

AN (Army-Navy) standard parts
AND standard designs
NAF (Naval Aircraft Factory) standard parts
AAF (Army Air Forces) standard parts

b. Industry standards, such as:

SAE standard parts and designs
ASA (American Standards Association) standard parts and designs
NAS (National Aircraft) standard parts and designs

c. Company standard parts and designs
d. Commercial standard parts

Government contracts require that government standards receive preferential usage, followed by industry, company, and commercial standards. Company or commercial standards may be used only when a government or industry standard does not exist for the item required.

STANDARDS HANDBOOK

A standards handbook contains drawings of standard parts and designs, and those normally available in an engineering department include relevant government and industry handbooks and the company standards handbook. The company standards handbook contains drawings of all standard parts and designs developed by the company. The standards drawing numbers are usually prefixed by a suitable letter identification. For instance, all Vultee Aircraft Company standard-part drawings are prefixed "VS," and all standard *design* drawings with "VSD." Company standards are usually prepared and issued by the standards engineer, who directs all company activities relating to standard parts and designs.

A member of the engineering library or files should be assigned the responsibility of maintaining all standards handbooks in a current and up-to-date condition, under the direction of the standards engineer. The duties of the person assigned this work include

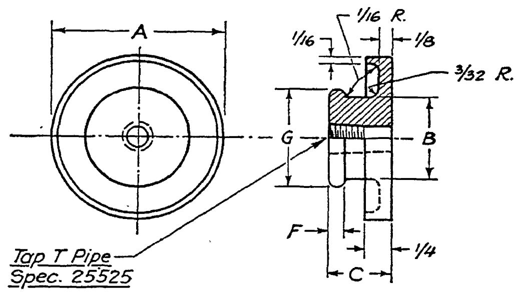
a. Maintaining the original or vellum copies of all standards.

b. Maintaining a "master copy" of each standards handbook, as an example of a correct, up-to-date copy.

c. Maintaining an "obsolete master copy" in which are accumulated one copy of all canceled and superseded standards.

d. Maintaining a record of all persons possessing copies of the standards handbooks.

e. Receiving all new and revised standards drawings, obtaining a sufficient quantity of prints of each, and immediately placing these in all standards handbooks—followed by the removal and destruction of superseded pages.



Dash Number	Tap T	A	B	C	F	G
1	1/8	1-1/2	23/32	7/16	1/8	27/32
2	1/4	1-3/4	7/8	5/8	5/32	1
3	3/8	1-7/8	1-1/16	5/8	5/32	1-7/32
4	1/2	2-1/16	1-11/32	3/4	3/16	1-19/32
6	3/4	2-5/16	1-5/8	13/16	3/16	1-13/16
8	1	2-11/16	2	1	1/4	2-1/4
10	1-1/4	3	2-9/32	1-1/8	1/4	2-17/32
12	1-1/2	3-1/4	2-3/4	1-1/4	1/4	3

EXAMPLE OF PART NUMBER:
VS 95-2 = Flange with 1/4 pipe thread.

MATERIAL:
Spec. QQ-A-411 Aluminum, half hard up to -6, quarter hard for -6 & larger.

NOTE:
This part is identical to A.C. 867 except that threads are full size.

Limits on dimensions are ±.010 unless otherwise specified.

DRAWN	Mason	9-11-41	LIMITS NOT SPECIFIED
TRACED			MATERIAL: Noted — HEAT TREAT: Noted — FINISH: —
CHECK	Kaider	9-25-41	
STRESS			CALC. WT. LBS. — ACTUAL WT. LBS.
APPR.			
APPR.			Flange - Pipe Welding

VULTEE AIRCRAFT
DIVISION OF AVIATION MANUFACTURING CORP.
DOWNEY, CALIF.

VS 95

FIG. 6:16.—Company standard-part drawing.

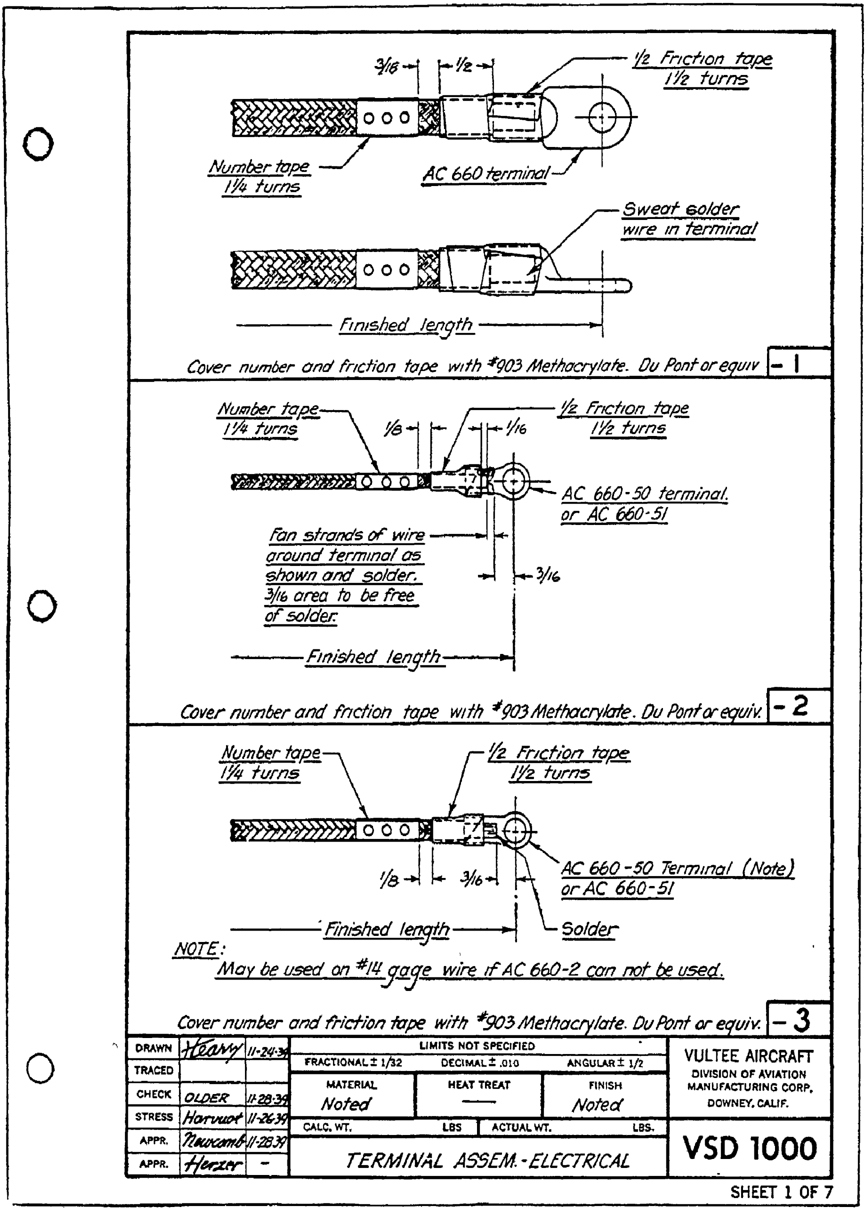


FIG. 6:17.—Company standard-design drawing.

New Company Standards

To insure uniformity in issuance of company standards it is necessary to provide centralized control of the assignment of standard-part numbers and the preparation of new standard drawings. This control is vested in the standards engineer. When the company has two or more operating divisions, the additional problem of coordinating standards between divisions is introduced, and the standards engineer at the company's home office then becomes standards coordinator for all divisions. In this case a single, uniform company standards handbook should be used by all divisions in order to avoid duplication of standards and to insure that all existing standards are available to each division.

When a new company standard is desired, the standards engineer must be furnished with a sketch and description fully explaining the new standard and its proposed usage. If the issuance of the new standard is approved, a standards drawing is prepared and copies furnished to all standards handbooks. If the request is rejected, the requester is given a full explanation of the reason.

Changes in Company Standards

When it is desired to change an existing company standard, a drawing-change request (see Chap. 12) must be prepared and forwarded to the standards engineer. The change request is investigated and its originator notified of the action to be taken. When an immediate change is required on a company standard, it is necessary to issue an engineering order deviation (see Chap. 11) on the standard involved and forward a copy of the EO to the standards engineer. Either the affected standard will be changed or a new standard issued. This procedure is not often necessary unless the company has several operating divisions, for the standards engineer is immediately available for consultation in the case of a self-contained organization.

Advance drawing changes (see Chap. 11) should not be issued against company standards or in lieu of a drawing for a new company standard unless approved by the standards engineer prior to their release. All changes on company standards are effective on future production, and it should be understood that parts on hand at the time of the change will be used until the stock is exhausted. When a standards change will affect interchangeability of the standard part, it is necessary to issue a new standard under a *new number* for the "changed" part and retain the previous version of the part in the standards handbook marked with the notation "Inactive for Design, Use (new standard)."

Release of Company Standards Drawings

A simple release procedure for company standards drawings is shown in Fig. 6:18. All new or changed standards drawings are forwarded by the standards engineer to Engineering Release with a "release request"

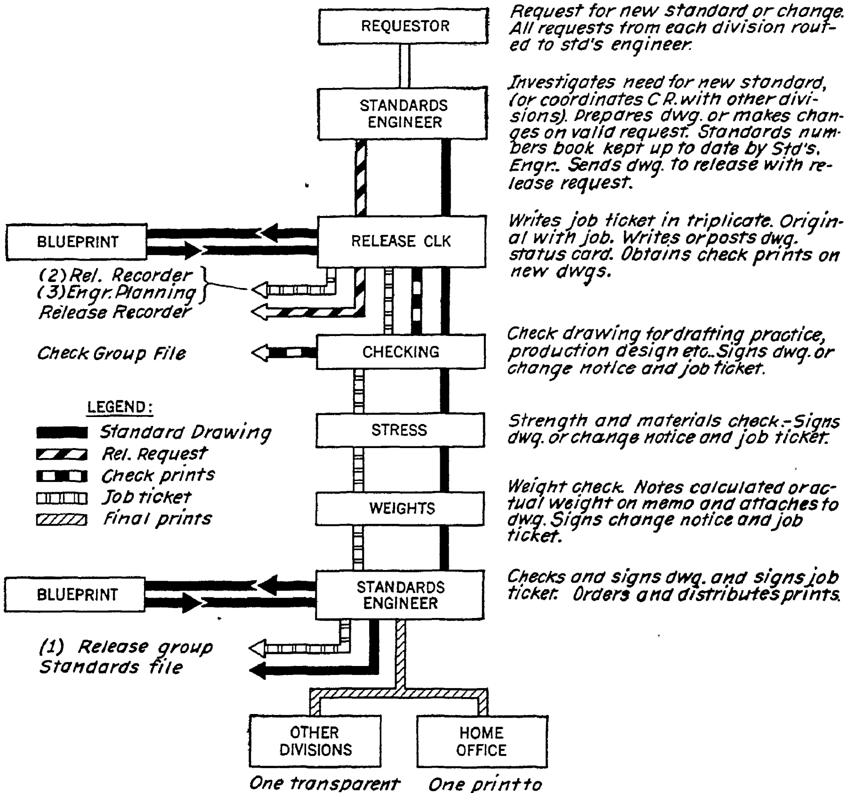


Fig. 6:18.—Release system for company standards drawing.

(see Chap. 9). Release routes the standard drawing to (1) Check, (2) Stress, and (3) Weight Control. These groups each check the standard drawing, coordinate desired changes with the standards engineer, and sign both drawing and job ticket as soon as the drawing meets with their approval. Following approval by the weight-control group the standard drawing is sent to the standards engineer for final approval and distribution of copies to all company standards handbooks. A duplicate tracing of the standards drawing is forwarded to each division when the corporate structure involves a multiplicity of operating divisions.

COMMERCIAL STANDARD PARTS

Commercial standard parts are any and all commercial parts universally usable without reworking that are not classified as government, industry, or company standards. The term "commercial standard part" does not pretend to fix any limitation that would prevent calling for any suitable part selected from commercial manufacturers' catalogues, except that this usage should be approved by the company standards engineer in order to avoid an unnecessary variety of commercial standards. When a commercial part is not usable strictly as purchased but requires reworking, there must be a company drawing made for the part, a drawing number assigned, and it cannot be known as a commercial standard. It may, however, become a company standard if it is universally usable after reworking.

Commercial standard parts are often transient in status, as government and industry standardizing groups frequently adopt as standards of their own newly developed commercial standards as soon as these have proved usable and reliable. When a new government or industry standard is issued on a part that previously was known as either a commercial or company standard, the new status of the part takes precedence over the former status, and all company standards drawings are superseded.

CHAPTER 7

DRAWING AND REPORT NUMBERING

Before a piece of drafting work can become a drawing, it must be assigned an identifying number. This number not only is an index for filing and recording the drawing but is also the *part number of the article described by the drawing*. Some companies have used separate drawing and part numbers, but this often led to confusion, and modern practice establishes the drawing number as the part number.

Each drawing should be assigned a number—not only manufacturing drawings of parts but also layout, proposal, mock-up, equipment, and building-improvement drawings. In fact, all drawings that may be used outside the originating group require a number.

Freehand sketches should not be considered drawings and need not be assigned numbers. Those made in production engineering groups are usually not preserved, except in the originator's personal file. Sketches made in development engineering groups, however, should be signed, dated (but not necessarily numbered), and filed for possible reference on patent matters.

DRAWING-NUMBERING SYSTEMS

Standardization of drawing identification does not exist, and there are nearly as many numbering schemes as companies engaged in product design. A majority of these, however, can be grouped into three broad classifications of (1) universal, (2) coded group, and (3) functional. The first provides only identifying numbers for the drawings; the other methods attempt to indicate also the nature of the drawing. In almost every case use of a coded-group or functional system ends in confusion, due either to lack of foresight when establishing the drawing numbering scheme or carelessness of personnel who issue and use the numbers. The universal system should be favorably considered whenever it becomes necessary to establish a drawing-numbering scheme. Coded and functional numbering systems have little to recommend their usage, for all eventually fail in fulfilling their purpose of providing identification of part usage and nature. The number may provide complete identifica-

tion when the drawing is released, but as soon as the part is used for another model or in a different application the drawing number loses its significance.

Universal Numbering System

This drawing-numbering system is used by some of the largest organizations engaged in product design, including General Motors Corporation and the Douglas Aircraft Company. A serial number is assigned each drawing for identification purposes, such as "100231" or "475051." No attention is given to maintaining significant numbers for particular assemblies or installations. The next number in numerical sequence is assigned to the next drawing, regardless of size, model, or title. In some cases the number is prefixed with letter or numeral to indicate the drawing size, such as *A*, *B*, *C*, *D*, and *R* or 1, 2, 3, 4, and 5. This practice cannot be encouraged, however, for drawing-size identification then becomes a part of the drawing number, leading to complications when revision requires redrawing on a larger sheet.

When an organization comprises several operating divisions, it is customary to allocate numbers in blocks to each division. Divisions then have complete jurisdiction over assignment of numbers from their respective number blocks. An example of divisional block allocation is seen in the following partial listing of General Motors drawing numbers:

	Assigned to
000,001 to 050,000	Delco Products Division, Dayton, Ohio
050,001 to 100,000	Yellow Truck and Coach Manufacturing Company, Pontiac, Mich.
100,001 to 149,999	General Motors Standard Parts
150,000 to 230,000	General Motors Standard Parts
230,001 to 232,000	Olds Motor Works Division, Lansing Axle Plant, Lansing, Mich.
232,001 to 252,500	Yellow Truck and Coach Manufacturing Company, Pontiac, Mich.
252,501 to 275,000	Saginaw Steering Gear Division, Saginaw, Mich.
275,001 to 277,500	Central Products, Detroit, Mich.
277,501 to 325,000	Yellow Truck and Coach Manufacturing Company, Pontiac, Mich.
325,001 to 380,000	Chevrolet Division, Detroit, Mich.
380,001 to 457,500	Olds Motor Works Division, Lansing, Mich.
457,501 to 477,500	Chevrolet Division, Detroit, Mich.
477,501 to 550,000	Pontiac Motor Division, Pontiac, Mich.

Coded-group Numbering System

The coded-group numbering system employs the first and second (sometimes only the first) numeral to indicate the general nature of the part described by the drawing. The remaining numerals are the drawing serial number. In some cases the basic number is prefixed with the project or model number, such as "27—3167." The numbering scheme used by Aireon Corporation to insure that all parts for similar units are contained in the same number group is an example of a simple coded-group numbering system:

Dwg. No. Group	Nature of Unit
13000	Control panels
14000	Castings and forgings
15000	Piping diagrams
18000	Flap cylinders
19000	Test procedures
22000	Cylinders
24000	Dampers and snubbers
28000	Oil filters and reservoirs
29000	Couplings and shutoff valves
30000	Hydraulic fuses
31000	Relief valves
32000	Restrictor valves
33000	Directional flow, cutover and shuttle valves
34000	Check valves
35000	Accumulators
36000	Brake valves and deboosters
40000	Regulators and pressure governors
47000	Hydraulic lock valves
50000	Freezeproof water drain
55000	Sequence, unloading and stop valves
56000	Swivels
58000	Sump pumps
60000	Turret valves
62000	Selector valves
65000	Hand pumps

All coded-group numbering schemes have a common deficiency in that they provide a limited quantity of drawing numbers for each group. In many cases it may seem that a given quantity (like 999) of drawing numbers will suffice for all future needs of a particular unit. Frequently this is not the case, and all available drawing numbers are issued. It is then necessary to establish an unorthodox method of extending the particular group, with resultant numbering-system complications.

Functional Numbering System

The functional drawing-numbering system is a refinement and extension of the coded-group system. The number is further coded to indicate not only the general nature of the part but its function as well. An example of this system is the drawing-numbering scheme shown in Fig. 7:1. This scheme, with various minor alterations to suit individual needs, is used by several major aircraft manufacturers.

This drawing-numbering scheme divides an airplane into a maximum of 99 functional units with a total of 1,000 drawing numbers provided for each. Each drawing number is prefixed with the relevant project number. Thus, "34—33001" is the landing-gear installation drawing for the airplane designed as project 34, and "72—33001" would identify the similar drawing prepared for project 72.

Drawing numbers ending in "001" are reserved for the principal installation drawings that are installed on the complete airplane assembly (XX—00002). Major installations end in "01" and assemble on the "001" installation drawings. For the sake of consistency the following "01" numbers should be assigned the designated installation:

XX—XX101	Fuselage installations
XX—XX201	Wing center-panel installations
XX—XX301	Wing inner-panel installations
XX—XX401	Wing tip installations
XX—XX501	Wing outer-panel installations
XX—XX601	Empennage installations
XX—XX701	Landing-gear installations
XX—XX801	Nacelle installations
XX—XX901	Power-plant installations

The drawing showing installation of the fuselage hydraulic system would be "XX—82101," and the fuselage electrical system installation would be "XX—78101."

Numbers between 10 and 99 should be used for assemblies and minor installations (such as the installation of a welded bracket). If additional numbers are required for assemblies and/or minor installations, these can begin at 902 and continue through 999. Detail drawings begin with 102 and continue through 900, omitting 201, 301, etc.

Parts relating to a certain functional unit should retain their basic numerical identification, regardless of where they are installed or what their next assembly may be. For example, a hydraulic-cylinder support bracket welded to the wing center panel should bear a hydraulic system number and show the center panel as its next assembly. Also, a control-system pulley bracket should bear the numerical identification of the

control system of which it is a part rather than that of the structure to which it assembles.

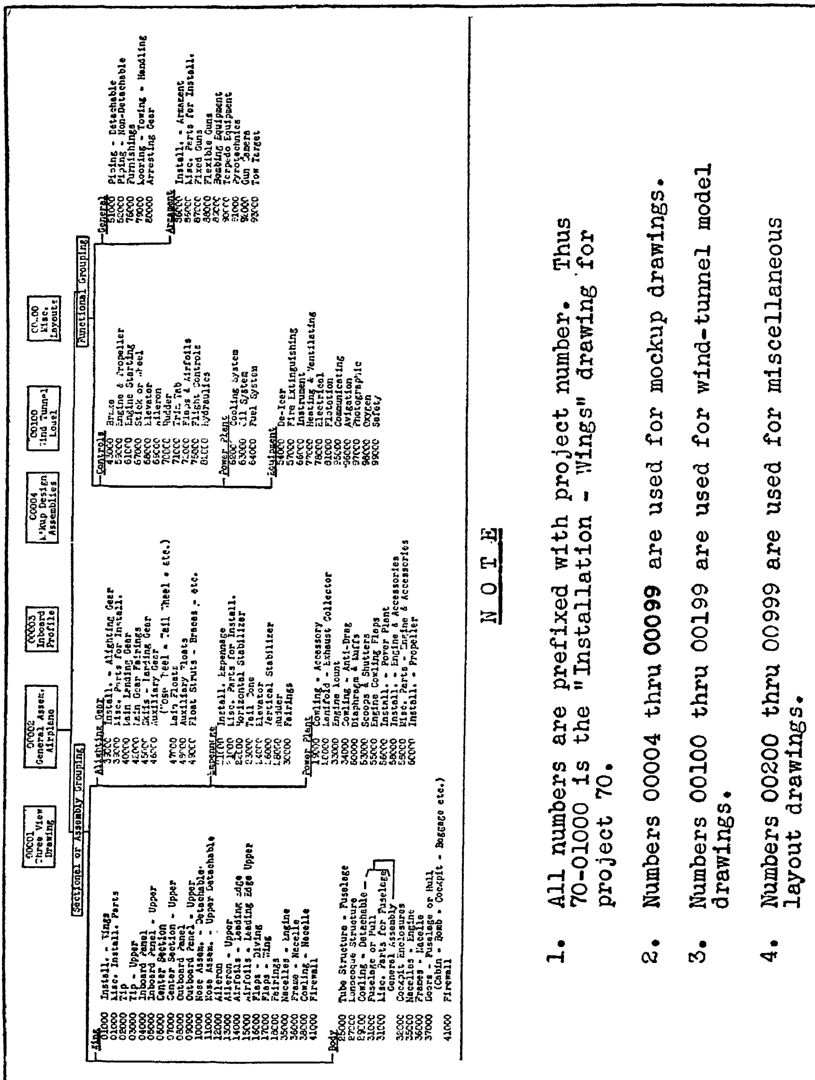


FIG. 7:1.—Functional numbering system suitable for aircraft drawings.

Layout drawings have a "9" prefix added to the basic functional number. Thus, the landing-gear layout for model 72 would receive drawing number "72—9—39001."

CONTROL OF DRAWING NUMBERS

The establishment of a standard procedure to effect the issuance, recording, cancellation, and control of drawing numbers is vitally important to successful operation of the engineering department. The elements of a practical system for effecting this end are relatively simple, and the success of its operation is governed by (1) the caliber of the numbers clerk and (2) management insistence upon rigid observance of rules relating to issuance and use of drawing numbers.

A member of the engineering planning group is designated as "numbers clerk." When the size of the department does not justify a planning group, it is customary to assign the responsibility for drawing-number control to the drawing-release group. All drawing numbers are assigned by the numbers clerk and recorded in the relevant numbers book. Engineering-file prints of released drawings (both new and changed) are routed to the numbers clerk to permit correcting the numbers books on new drawings and maintaining an active record of revised requirements on changed drawings.

NUMBERS BOOKS

Master numbers books are maintained by the numbers clerk, with separate books being provided for every model and for layout and standards drawings. These books should be in vellum form, and a "direct-lineprint" copy used by the numbers clerk for daily entries. Another copy should be maintained in the records vault. Additional copies can be issued upon request by a department head and approval by the chief draftsman. Revised pages for all books should be issued each week. The master numbers books (both vellum and copy) should never be removed from the planning or release group. The specimen drawing numbers-book page shown in Fig. 7:2 provides the following information:

Page No. All pages of each numbers book are consecutively numbered.

Basic Model. Model covered by numbers book.

Project No. and Kind. Project number assigned to the basic model and the nature of the project.

Division. Used when company has more than one operating division.

Dwg. No. Number assigned to drawing.

Dwg. Title. Complete title assigned to drawing.

Next Assembly. Number of next assembly of drawing. If drawing is used in a number of places and has several next assemblies, list these.

Used on Models. Provides a rough interchangeability parts list in cases where the quantity of related models is small. When a variety of models are involved, it is best to dispense with this column and provide a separate interchangeability list.

DRAWING NUMBER ASSIGNMENT RECORD

PAGE NO. 2
BASIC MODEL 252
Burbank DIVISION

PROJECT NO. AND KIND 25-Selector Valve

DRAWING NUMBER	DRAWING TITLE	NEXT ASSEMBLY	USED ON MODELS 251	252	253	254	255	SUPERSEDES	REMARKS	DATE ISSUED NO CLERK	DRAFTSMAN GROUP	RELEASE & DRAWING SIZE
25-101	Housing - 6 GPM Selector Valve	25-002		x				By 25-111	Effective 252-1 thru 50	4-18-45 EWC	D J Williams Hydraulics	4-28-45 D
25-102	Sleeve - 6 GPM Selector Valve	25-002		x	x					4-18-45 EWC		4-28-45 B
25-103	Piston Assem - 6 GPM Selector Valve	25-002		x	x					4-18-45 EWC		4-28-45 B
25-104	Head - 6 GPM Selector Valve Piston	25-103		x	x					4-18-45 EWC		4-28-45 A
25-105	Body - 6 GPM Selector Valve Piston	25-103		x	x					4-18-45 EWC		4-28-45 A
25-106	Shaft Assem - 6 GPM Select Valve Crank	25-002		x	x					4-18-45 EWC		4-28-45 C
25-107	Shaft - 6 GPM Selector Valve Crank	25-106		x	x					4-18-45 EWC		4-28-45 C
25-108	Pin - 6 GPM Selector Valve Crankshaft	25-106	x	x	x	x	x			4-18-45 EWC		4-28-45 A
25-109	Bearing - 6 GPM Selector Valve Crankshaft	25-002		x	x					4-18-45 EWC		4-28-45 B
25-110	Cover - 6 GPM Selector Valve Sleeve	25-002	x	x	x	x				4-18-45 EWC	D J Williams Hydraulics	4-28-45 B
25-111	Housing - 6 GPM Selector Valve and Thermal Relief	25-002		x	x			25-101	Effective 252-51 & up	5-8-45 GTA	R P Perry Hydraulics	5-12-45 C

FIG. 7:2.—Numbers book used to record drawing-number assignment.

Supersedes. Number of drawing superseded by the new drawing. At the entry for the superseded drawing a notation of "By (new dwg. no.)" is made.
Remarks. Used when a drawing is voided or canceled and for other pertinent information.
Date Issued and No. Clerk. This dual-entry space provides for date when drawing number is issued and for initials of clerk assigning number.
Draftsman and Group. Draftsman assigned the new drawing number and his engineering group.
Release and Dwg. Size. The drawing size is entered at the time when drawing number is assigned. The drawing release date is entered when drawing is completed and cleared through release system.

Engineering-file Prints Routed to Numbers Clerk

The engineering-file prints of each drawing release are routed to the numbers clerk who uses the prints to correct the numbers books and then forwards the prints to engineering files. The numbers clerk checks number, title, next assembly, model requirements, and other pertinent data on prints of *new drawings* with the original entry in the numbers book and changes the book as necessary to agree with the drawing. At this time the "released date" is entered. When prints of *changed drawings* are received, the numbers clerk checks all pertinent data against the numbers-book entry and makes necessary changes and additions.

The numbers clerk should check on the first working day of each month all new drawing numbers that have been issued for over a month and the drawings not released. All drawing numbers that are found to be no longer needed should be voided.

ISSUANCE OF NUMBERS

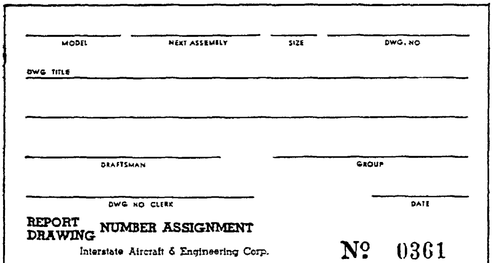
Drawing numbers are issued by the numbers clerk, upon presentation of a drawing-number assignment request form in duplicate, approved by the requestor's supervisor. The supervisor is responsible for the drawing title conforming to company standards. A separate request is required for each number issued. The numbers clerk enters the number on the request, retains the original, and gives the copy to the requester. The specimen drawing-number request form shown in Fig. 7:3 provides for

Model. Model or models that drawing is prepared for.
Next Assembly. All next assemblies of drawings are listed.
Size. Size of sheet that drawing will be placed on.
Dwg. No. Number assigned to drawing by numbers clerk and simultaneously entered in appropriate master numbers book.
Dwg. Title. Exact title that will appear on completed drawing.

Draftsman. Name of person preparing drawing.
Group. Draftsman's engineering group.
Dwg. No. Clerk. Name of person issuing drawing number.
Date. When drawing number was issued.

This form is also used for issuing report numbers by striking out the word "drawing" in the title. When the form is used for drawing-number assignment, the word "report" is deleted.

Drawing numbers should not be reserved or issued in blocks (except to another division) but are issued consecutively as required. Unless this rule is observed, it will be found that blocks of unused numbers will


MODEL NEXT ASSEMBLY SIZE DWG. NO

DWG TITLE

DRAFTSMAN GROUP

DWG NO CLERK DATE

REPORT
DRAWING NUMBER ASSIGNMENT
Interstate Aircraft & Engineering Corp.
№ 0361
FORM 189-D

FIG. 7:3.—Form used for request and issue of drawing and report numbers.

be scattered throughout the numbers books, resulting in rapid consumption of all available numbers when coded-group or functional numbering is used. This condition results because it is impracticable for engineering supervisors to forecast the exact quantity of drawings required for a given job.

VOIDED AND CANCELED NUMBERS

There are many occasions where a drawing number is assigned but subsequent events make the drawing unnecessary or undesirable, and the drawing is not prepared. In other cases, a drawing may be prepared and released, then found unsuitable, with the result that it is no longer required. Numbers issued to these drawings must never be reassigned, but should be *voided* or *canceled,* depending upon the circumstances. Attempts to reassign these drawing numbers are certain to result in difficulties arising from the possibility that the same number may be assigned to two drawings in the case of reinstating a canceled drawing.

Voided numbers are those for which drawings have not been released and which circumstances make unnecessary. These should be marked "Void" in the numbers book affected, with date and authorizing signature entered in the "Remarks" column. *Canceled* numbers are those for

which drawings have been released but which are no longer required. These are marked "Canceled" in the numbers book affected, with the date and drawing change effecting cancellation shown under "Remarks." Voided and canceled drawing numbers should not be reissued to another drawing but can be reinstated for a drawing bearing their original title and model designation. Canceled drawings require a drawing-change notice, as explained in Chap. 12, and changes to remove the canceled drawing's requirements must also be made on all next assemblies affected.

The numbers clerk should receive written notification on all canceled and voided drawing numbers. This notification should always state the superseding number (or note that there is none) and originate with the supervisor responsible for the cancellation or voiding. The superseding number is entered in the "Supersedes" column of the relevant numbers book and prefixed with "By." Thus: "By 12—1234."

DRAWING-NUMBER CHANGES

Drawing-number changes require approval of the chief draftsman, and the numbers clerk should receive written notification of all changes. Since considerable expense and confusion may result from drawing-number changes, they should be avoided whenever possible. Records maintained by the manufacturing, sales, accounting, and other departments are based upon drawing numbers, and all must be changed whenever a number is altered.

Parts may be drastically redesigned without changing their drawing number if the new design is completely interchangeable with the original part. To be completely interchangeable it must be possible to replace the original part with the new design without the necessity of cutting, bending, filing, drilling (except back-drilling to pick up existing rivet or bolt holes in the attaching structure), or other alterations.

Under no condition should the drawing number be changed when new usage is found for an existing part. This condition frequently occurs during the design of new models or products when it is found that some existing production parts can be incorporated in the new design without change. When an existing part can be used with slight modification or alteration, a new drawing is prepared and assigned a new number. In these cases it is customary to place a note "Similar to (dwg. no. of existing part)" on the new drawing to assist the tooling and manufacturing-planning departments.

In general, a new drawing under a new drawing number should be prepared only when a part or assembly is so changed that (1) perform-

ance or durability is affected to such extent that the superseded parts must be discarded for reasons of safety, unsatisfactory functioning, or standardization or (2) dimensional interchangeability of parts, subassemblies, or complete articles is affected.

Some companies follow the practice of assigning a new drawing number when radical material changes are made. This procedure cannot be recommended unless interchangeability is also affected as the drawing-change letter is sufficient identification for all records maintained in the factory. From a use standpoint it is not important whether the part is an aluminum-alloy forging or a steel weld assembly if both designs perform the required function and are dimensionally interchangeable.

LEFT- AND RIGHT-HAND OPPOSITE PARTS

The expression "left- and right-hand opposite," with reference to detail parts, assemblies, or installations, means that one is the mirror image (exact reverse) of the other. Both may be installed on the same side of the completed article. Considerable drafting time can be saved by preparing a drawing only for the left-hand version and adding suitable suffixes to the basic drawing number to provide separate identity for each form.

The following methods of distinguishing between left- and right-hand opposite parts are in general use:

a. The basic drawing number indicates the left-hand version, and a —1 suffix is added to identify the right-hand form. Many western and central manufacturing concerns use this method which is employed for the specimen drawings shown in Chap. 6.

b. A —*L* suffix is added to the basic number to identify the left-hand version, and a —*R* suffix designates the right-hand opposite form. This method is used by many eastern manufacturers.

c. A —1 suffix identifies the left-hand version, and —2 the right-hand opposite, a system used on Army-Navy Aeronautical Standard drawings and recommended in Army-Navy Aeronautical specification AN—D—12 for drawings of aircraft parts.

d. Drawing numbers are assigned in pairs, such as 130421 and 130422, with the odd number (130421) identifying the left-hand part and the even number (130422) its right-hand opposite form. When a right-hand opposite form does not exist, the even number remains unused.

Irrespective of the method of distinguishing between left- and right-hand opposite parts, a suitable notation must appear adjacent to the title block, calling attention to existence of a right-hand opposite ver-

sion. A drawing number of 15—1234 being assumed and use of —1 for the right-hand part, the following notation is customary:

15—1234 LH SHOWN
15—1234—1 RH OPPOSITE

Similar notation should be employed with other methods of identifying opposite-hand parts. In no case should the drawing title indicate that the left-hand version is the one drawn, as complete information cannot be given in the title, and duplication of partial data may lead to confusion. When an assembly is noted where the left-hand form is shown and the right-hand is opposite, care must be used to insure that all detail parts are drawn for the left-hand assembly and noted as being opposite for the right-hand.

When very *minor* differences exist between the left- and right-hand versions of a part (such as a cutout in the right-hand version only), it is possible still to use a single drawing for both "hands." In this case a separate view is shown of the affected area of the right-hand form and noted as "RH Only." This practice should be used with caution, however, as it is easy to become involved in complications that confuse the manufacturing departments and cause costly scrap and rework out of proportion to the expense of preparing a separate drawing for the similar right-hand part. In such cases the notation adjacent to the title block becomes (assuming the conditions specified in the preceding example):

15—1234 LH SHOWN
15—1234—1 RH OPPOSITE AND NOTED

NUMBERS FOR PURCHASED PARTS

Drawings should not be made or company drawing numbers assigned to purchased parts unless the part is altered for company use. In such cases a drawing must be made to show the alteration required, and a company drawing number assigned. See Fig. 7:4 for specimen drawing of a modified purchased part. It should be observed that a note appears on the drawing, specifying the following information:

(Part number, name, and quantity required)
COMMERCIAL PRODUCT EQUAL TO AND INTERCHANGEABLE WITH
(Manufacturer's name and catalogue number, if any)
ALTERED IN ACCORDANCE WITH THIS DRAWING

When commercial and/or patented articles are used exactly as produced by their manufacturer for commercial use or as specialties for the

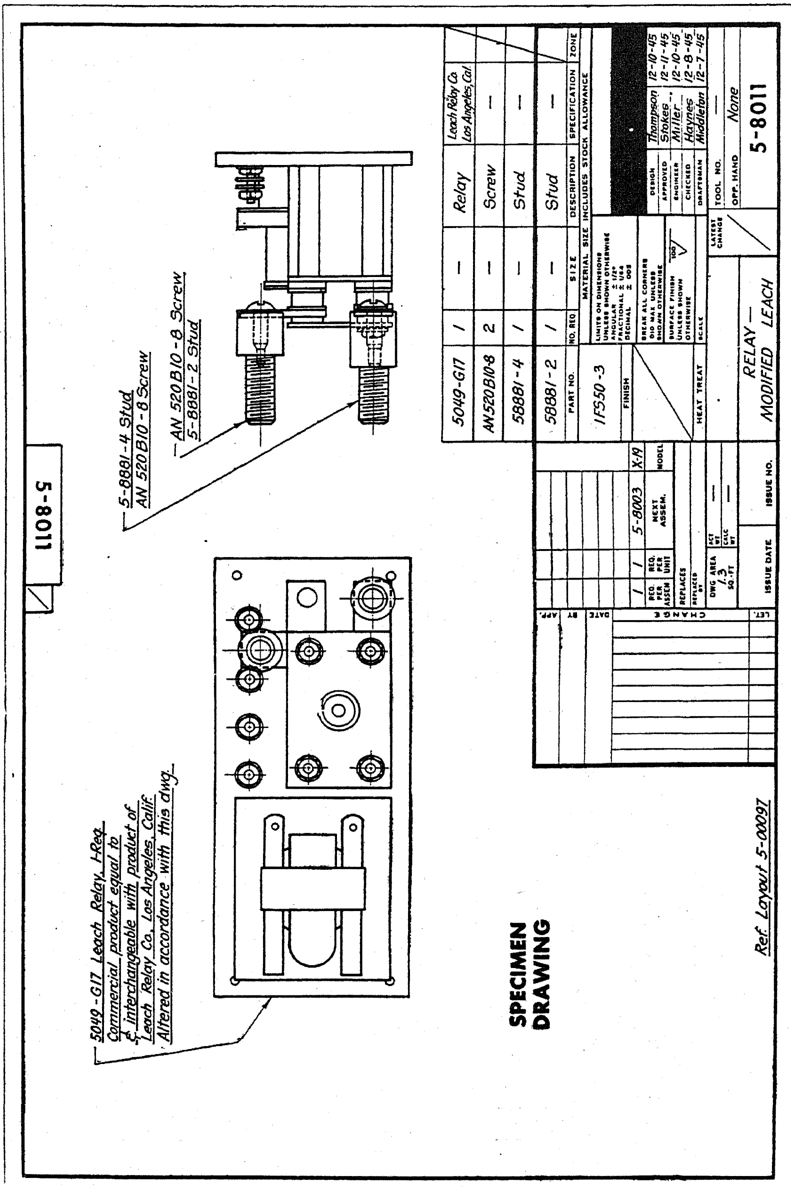


FIG. 7:4.—Identification of modified purchased part.

purchaser, their manufacturer's name, address, and identifying number should appear as a call-out on the drawing showing the assembly or installation of the article. Parts, such as bolts, pipe fittings, and machine screws, that have been commercially standardized by a recognized so-

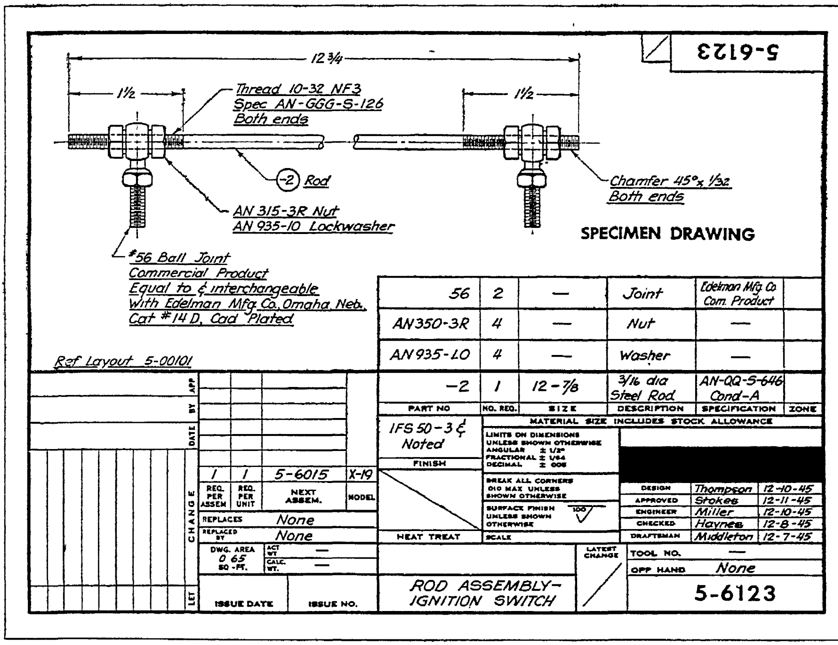


FIG. 7:5.—Identification of commercial part. Quantity required can be omitted when bill-of-material used.

ciety or association do not require the manufacturer's name and address and should be noted on drawings as

(Name of article, size, and quantity required)
COMMERCIAL STANDARD

Parts made by one or more manufacturers that have not been commercially standardized but may be used interchangeably, such as electrical parts, belts, and bearings, should be called out on drawings as

(Part number, name, and quantity required)
COMMERCIAL PRODUCT EQUAL TO AND INTERCHANGEABLE WITH
(Manufacturer's name, address, and catalogue number showing article)

See Fig. 7:5 for a specimen drawing showing this condition.

Parts made by one or more manufacturers, but where a portion of the article must conform to a certain specification should be identified on drawings similar to the following example:

7361—L SWITCH 2—REQ.
COMMERCIAL PRODUCT WITH LUMINOUS MATERIAL ON TIP CONFORMING TO SPEC. 63—4 EQUAL TO AND INTERCHANGEABLE WITH BUSCH MFG. CO., HARTFORD, CONN., CATALOGUE 26B

When a commercial part is used in several places on a drawing, it is advisable to place an item number enclosed in a triangle at each call-out and show a note on the drawing to identify the item number. This avoids placing complete identification at each place where the commercial part is called out.

REPORT NUMBERING

All reports, specifications, and similar documents prepared in the engineering department require identifying numbers. Various schemes have been devised for report numbering, including elaborate coding to indicate the nature of the document. Unless careful planning that traces each possible condition to its ultimate conclusion is used in preparing these schemes, complications and contradictions will arise during employment of the numbering system.

The prime purpose of a report number is as a means of identifying and filing the document, and it is recommended that simple consecutive numbering be employed. Report numbers then begin at "1" for the first report issued and are assigned in consecutive order, regardless of the nature of the document. When several divisions of a company are involved, a letter prefix should be used to identify reports originating in each division, such as "*E*—10," "*D*—72," and "*W*—203."

When several variations of a certain report are required, a related series of reports to be issued, or alterations of a prime specification desired, a basic number can be assigned to designate the group and each individual report identified by a dash number. Thus: "Report 203—1," "203—2," "203—3," etc.

Report numbers are issued by the numbers clerk in the same manner as drawing numbers. A report-numbers book is maintained, using a procedure similar to that for the drawing-numbers books. A suitable report-numbers book form is shown in Fig. 7:6, which lists the following information:

Page No. All pages of the numbers book are consecutively numbered.
Report Nos. First and last basic report number appearing on page are listed.

REPORT NUMBER ASSIGNMENT RECORD

PAGE NO. 20
REPORT NUMBERS 203
Downey DIVISION

REPORT NO	DASH NO	TITLE	BASIC MODEL	SUPERSEDES	REMARKS	DATE ISSUED NO CLERK	ISSUED TO GROUP	RELEASE & KIND
203	-1	Handbook of Erection and Maintenance Instructions	A11-GB2			6-13-44 RBC	R R Cook Handbook	11-7-44 B/P
	-2	" " " " " " "	A12C&D			8-27-44 RBC	R R Cook Handbook	3-2-45 B/P
	-3	" " " " " " "	P-48	By 203-8	Cancelled 12-7-45 GTA	4-19-45 RBC	R R Cook Handbook	9-27-45 B/P
	-4	" " " " " " "	BC-1			6-7-45 WLM	J H Steven Handbook	10-9-45 B/P
	-5	" " " " " " "	YA-19			6-15-45 EWC	J H Steven Handbook	12-3-45 Offset
	-6	" " " " " " "	BC-2		Void 12-6-45 GTA	6-23-45 EWC	J H Steven Handbook	— B/P
	-7	" " " " " " "	63			8-15-45 EWC	JH Steven Handbook	Offset
	-8	" " " " " " "	P-66	203-3		12-7-45 GTA	R R Cook Handbook	Offset

FIG. 7:6.—Numbers book used to record report-number assignment.

Division. Used when company has more than one operating division.

Report No. Number assigned to report. Basic number is entered on first line only when page is used for dash-numbered reports.

Dash No. Used when dash numbers identify related reports. One page is established for each basic number.

Title. Complete title assigned to report.

Basic Model. Model or models affected by information contained in report.

Supersedes. Number of report superseded by new report. At the entry for the superseded report a notation of "By (new report no.)" is made.

Remarks. Used when report is voided or canceled and for other pertinent information.

Date Issued and No. Clerk. This dual-entry space provides for date when report number is issued and for initials of clerk assigning number.

Issued to and Group. Person assigned the report number and his engineering group.

Release and Kind. The report release date is entered when completed and cleared through release system (see Chap. 14). The method of reproducing the report (blueprint, ditto, photo-offset, etc.) is entered in the lower half of this dual-entry space.

SUMMARY

The information contained in this chapter can be briefly summarized as follows:

a. Each drawing must be assigned a number. This number is not only an index number for filing and recording the drawing but also the part number of the article described by the drawing.

b. Various drawing-numbering systems are in use. Some attempt to identify the drawing's nature by its number; others provide only a serial number for the drawing. The latter method is considered preferable, for its application is simple, and mistakes are less likely.

c. The establishment of a practical, efficient procedure to effect the issuance, recording, cancellation, and control of drawing and report numbers is vital to efficient operation of the engineering department.

d. A responsible member of the engineering department should be designated as "numbers clerk" to maintain numbers books for all drawings and reports. All drawing and report numbers are issued by this clerk. One copy of all new and changed drawings and reports are routed to the numbers clerk to permit correcting the books on new releases and revising requirements on change releases.

e. Drawing numbers are not changed after release of the drawing unless subsequent changes affect interchangeability or the original part is found unsatisfactory.

f. One drawing can describe two parts when these are left- and right-hand opposite forms. A suitable suffix (such as "—1") is added to the basic drawing number to identify the right-hand opposite version, but a drawing is not made for this part.

g. Drawings are not made of and drawing numbers not assigned to purchased parts except when alterations are required before the part can be used.

h. Report numbers are assigned in numerical sequence beginning with "1" for the first report issued. Dash numbers may be suffixed to the basic number to identify related reports.

CHAPTER 8

DRAWING FORMS AND TITLE BLOCKS

A variety of drawing forms and title blocks are in use, but the majority can be grouped into two general classifications. Drawing forms are generally based upon multiples of either 8½ by 11 in. or 9 by 12 in. Title blocks are either used with a separate bill of material or arranged for listing materials directly upon the drawing.

Drawing forms based upon multiples of 8½ by 11 in. are considered preferable as their prints are readily stored in standard letter-size filing cabinets. Also, standard mailing envelopes readily accommodate prints of this size. This is the arrangement listed as preferable in Army-Navy Aeronautical specifications AN—D—12 and AN—D—13, governing the preparation of drawings for aircraft, engines, and accessories.

A separate bill of material is considered preferable to the method of specifying materials directly upon the drawing. Many manufacturing groups have little need for actual drawings but are primarily concerned with the information contained in a bill of material. These activities can be furnished copies of the bill of material only, with considerable saving. Another consideration is that revisions to the materials list may frequently cause redrawing when the list is placed directly upon the tracing. When a separate list is used, the bill of material can be revised and reissued without reissuance of the drawing. This may save several hundred square feet of blueprint paper when a large drawing is involved.

DRAWING FORMS

Drawing forms, for the purpose of this discussion, are the standard size and arrangement of sheets used for preparation of drawings. Whether the drawings are made upon paper, cloth, or metal, the basic considerations are the same, and the choice of material has no bearing upon their arrangement. The preferable standard drawing sizes are listed in the table following. All except the roll-size drawings should be available as printed forms, complete with title block and border. Roll-

size drawings are prepared by cutting a suitable length of tracing medium from its roll and impressing the title block thereon with a rubber stamp.

Size symbol		Size in inches
Letter	No.	
A	1	$8\frac{1}{2} \times 11$
B	2	11×17
C	3	11×34
D	4	17×22
G	5	22×34
R	6	36×144 (max.)

See Fig. 8:1 for recommended arrangement of these drawing forms.

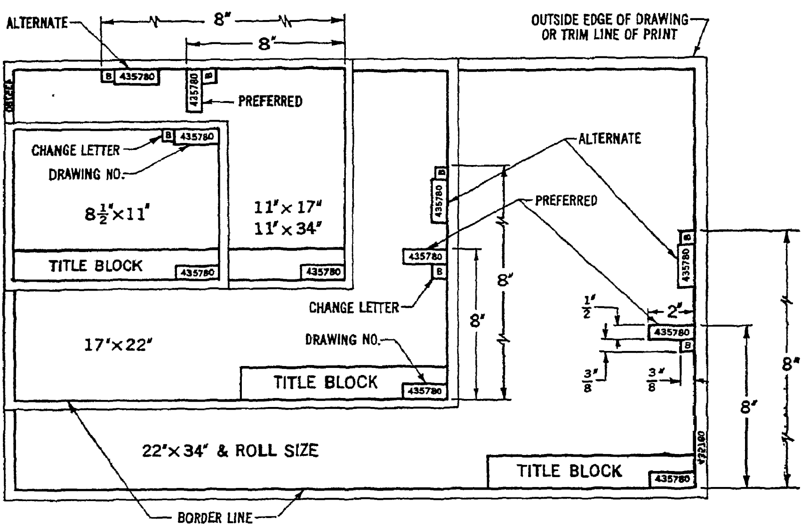


Fig. 8:1.—Size of drawings and arrangement of drawing forms.

The size symbol is used by Release and engineering file records for rapid identification of drawing sizes. It is desirable that the maximum width of roll-size drawings is limited to 36 in., and filing and printing these drawings is simplified by standardizing upon a 36-in. width for *all* roll-size drawings. The length of roll-size drawings should be limited to 144 in. When longer drawings are required, they should be prepared as

sets comprising two or more sheets, each bearing the same drawing number and having notations of "Sheet 1 of 2," "Sheet 2 of 2," etc., placed below the drawing number.

Zoning of Drawings

All roll-size drawings should be provided with vertical zoning to permit rapid location of items listed on notices of change and bills of material. Large or complex drawings should also provide vertical zoning in order to facilitate further the location of specific drawing areas.

Horizontal zoning is accomplished by dividing the lower border of the drawing into zones of 11 in. each, beginning with the right-hand border as "zone 0" and numbering toward the left. Each zone is marked w th the proper numeral (except zone 0), placed in a ½-in. square parallel to and coincident with the lower border line (see Fig. 8:2).

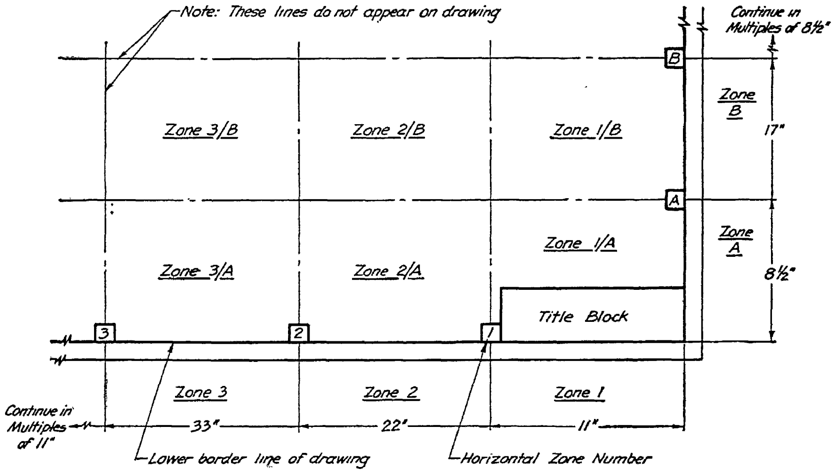


Fig. 8:2.—Zoning of drawings.

Letters should be used for vertical zoning, beginning with the lower border as the reference point and continuing toward the top. Each zone is 8½ in. wide and marked with the proper letter placed in a ½-in. square as shown in Fig. 8:2. The first zone is identified by the letter *A*, and zone designation continues in alphabetical order.

The zoning corresponds to the folding of prints, being in increments of 11 and 8½ in., to facilitate rapid location of zones when unfolding prints. When prints are folded to another size, such as 9 by 12 in., the zone spacing should be altered accordingly.

The zone system can be utilized for the location of (1) part call-outs on bills of material, (2) change items on notices of change, (3) cross-referencing sectional cutting planes with the location of the section, and (4) cross-referencing drawing views with the location of the enlarged detail view. In the case of sections and views it is customary to place the zone number of the area in which the section or enlarged view is located adjacent to the cutting plane or view circle and enclosed in a ¼-in. square. Thus, "*A—A* $\boxed{3}$" can indicate that the corresponding section will be found in zone 3; "B $\boxed{7}$" signifies that the corresponding enlarged detail view is located in zone 7. At the location of the actual section or detail view the zone location of the corresponding cutting plane or view circle should be shown following the call-out. Thus, if the cutting-plane of section *A—A* is located in zone 5, the call-out at the sectional view will be "Section *A—A* $\boxed{5}$." This system provides positive means of cross reference for section and detail views and their corresponding locations in the body of the drawing.

TITLE BLOCKS

The drawing title block should show the company name and address; drawing title, number, and date; heat-treatment; finish; material and material specification; names of draftsman and checker; drawing number of next assembly using the part; scale; and tolerances. These are minimum requirements as established by Army-Navy Aeronautical specifications AN—D—12 and AN—D—13. In actual practice additional information is required fully to implement usage of the drawing.

All drawings should show the drawing number in two locations as an aid to filing. The drawing number should appear in the normal title-block location in the lower right-hand corner of the drawing and be repeated in a space ½ by 2 in., in the locations and manner shown in Fig. 8:1. On roll-size drawings the number should also be repeated at both ends of the drawing so that it can be seen without unrolling the drawing. These numbers should be placed at opposite corners on the reverse size of the drawing, near the margins of 6-in. wide protector strips provided as part of each end of the tracing. Use of these protector strips requires simply that the length of tracing medium be 12 in. longer than actually needed for the drawing. It will be found that the protector strips largely eliminate marginal fraying and soiling of the drawing.

TITLE BLOCK INCORPORATING BILL OF MATERIAL

Figure 8:3 shows a title block providing for both a bill-of-material and drawing-change record. This block measures approximately 3¼ by

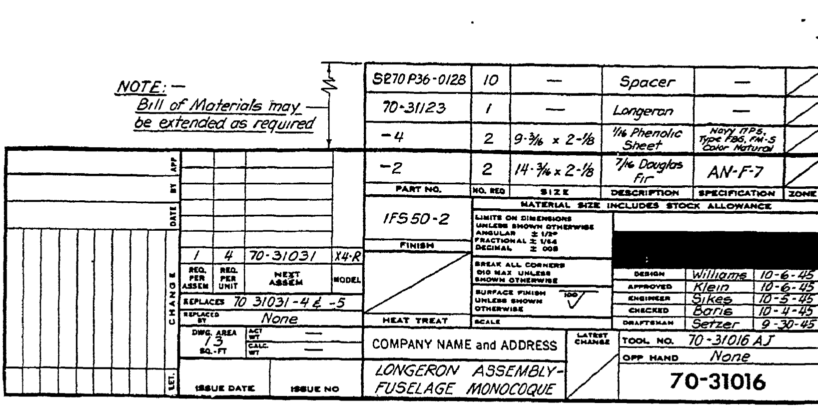


FIG. 8:3.—Drawing title block providing a bill-of-material.

10½ in. and provides all information normally required for production drawings in the following manner:

Change Block. Located at the left end of the title block for recording drawing changes. Columns provide for change letter, nature of change, date, draftsman's signature, and approval signature. When a notice of change is used, the "Change" column is not necessary.

Requirements per Assem., Requirements per Unit, Next Assembly, and Model. This "model-requirements" block lists next assembly drawing numbers for each model affected by the drawing. Quantities required of the part described by the drawing are indicated, both for the next assembly and for the complete article.

Replaces and Replaced by. Filled in with either the word "None" or the drawing number involved.

Dwg. Area in Square Feet. Entered by release group before sending new drawing to Blueprint.

Actual Weight and Calculated Weight. Entered by weights group. Calculated weight listed when drawing is released; actual weight added after part is made.

Issue Date. Issue date is stamped on prints by Release prior to distribution.

Issue No. Entered by Release prior to distribution of prints.

Part No., No. Required, Size, Description, Specification, and Zone. The strip in the top, right-hand portion of the block provides columns for the bill of materials. If a detail drawing, the one line is sufficient for material data, and the "Part No." space is crossed out. If an assembly drawing, the columns are extended upward sufficiently to provide a 7⁄16-in. wide line for each part. One item is entered on each line, using the "Part No." column for identifying each.

Finish. Nature of paint, plating, or other protective finish required. If a company finish specification is prepared for the completed article, its number alone is sufficient.

Heat-treat. If part requires heat-treatment, the necessary data are given together with applicable specification number.

Name and Address of Company. Printed in oblong space directly below the "heat-treat" block.

Dwg. Title. Entered in oblong space directly below name and address of company.

Tolerances, Corner Radii, and Surface Finish. Selected to meet needs of the company.

Scale. The scale of the drawing appears here.

Classified Data Block. Located directly above the signature block. Produces white oblong on blueprints for stamping prints of classified drawings as "Secret" or "Confidential." Proper security classification is also printed in space above block.

Signature Block. Provides for signatures and dates by draftsman, checker, project engineer, customer, and chief engineer.

Latest Change. Current drawing-change letter is entered with pencil. Erased and changed for each drawing revision. A slant line is used when there are no changes.

Tool No. Special tools required to manufacture part are listed here, such as jigs and fixtures. If space is not adequate, place "Noted" here and list on drawing.

Opposite Hand. If the part shown exists in a right-hand opposite form, the part number of the opposite hand is entered. If no opposite hand, enter "None."

Dwg. No. Entered in oblong space directly below "Opposite-hand Space," preferably with a numbering stamp.

Stock Size of Materials

The drawing title block shown in Fig. 8:3 and the specimen bill of material shown in Fig. 8:5 provide spaces for indicating "size" and "description" of materials. *Size* is the raw-stock dimensions to which the material is cut prior to manufacture of the part. *Description* is the form of material to be purchased.

The dimensions shown in the *size* space should always be raw-stock dimensions unless otherwise noted on the drawing and should not repeat dimensions given as part of the description. The *first* dimension should always be stock length, and the *second* should be stock width. Stock thickness is normally specified in the description space. In the case of rectangular bar-stock, thickness *and* width are specified in the description space. The abbreviations *SW* for stock width and *SL* for stock length are unnecessary and should not be used.

The statement in the title block shown in Fig. 8:3, to the effect that "material size includes stock allowance," means that all size data includes stock for machining and trimming during manufacture of the part. This permits the material-control department to order sufficient material by simply multiplying the material required for one part by the quantity of parts involved. To insure uniform raw-stock allowances it is necessary to establish standard manufacturing allowances and make certain that these are uniformly applied to each drawing. The following stock allowances will be suitable in a majority of cases:

a. Sheet and Plate Stock. Calculate the width and length of a square or rectangle that will enclose the *flat pattern* of the part, and add ⅛ in. to each dimension to obtain stock width and stock length.

Note: Add 3 in. to normal stock dimensions of parts that are formed by *drawing* on drop hammer or mechanical press.

b. Tubing. Add ⅛ in. to the actual length to obtain stock length of tubes having square ends; add 1 in. for each angle cut or profiled end.

c. Bar, Square and Rectangular. Add 1/32 in. to all sides requiring machining. Add ⅛ in. to the actual length to obtain stock length for bars having a width less than 2 in.; add ¼ in. for bars having a width of 2 in. or greater.

d. Rod and Bar, Round and Hexagon. Add 1/32 in. to diameter or across flats if machining is required. Add ⅛ in. to the actual length to obtain stock length for bars less than 2 in. in diameter or across flats; add ¼ in. for bars 2 in. or greater.

e. Lumber. Add ⅛ in. to *width and thickness* of all parts made from lumber to obtain stock sizes. Add ⅛ in. to the actual length to obtain stock length of parts having a maximum width or thickness less than 2 in. Add ¼ in. for parts 2 in. or greater.

Note: The "length" of lumber is always the dimension along the grain. The width of lumber is always the dimension across the grain, regardless of how the piece is cut from the board.

f. Plywood. Calculate stock width and length as described for sheet stock in subparagraph *a*.

g. Welded Spacers. Increase the stock length of welded spacers that require machining of the ends after welding by adding ⅛ in. to the length desired after machining. Show the finished length on the assembly drawing.

When material size and description are properly listed, the title-block or bill-of-material entries will appear similar to the following:

Size	Description	Specification
Noted	Aluminum alloy casting	AN—QQ—A—366
Noted	Aluminum alloy forging	FED—QQ—A—367 Class 1
9¾ × 3 9/16	0.072 CM steel sheet	AN—QQ—S—685 Condition *A*
12¾	⅝ OD × 0.035 × 4130 steel tube	Commercial
4 7/16 × 2⅛	0.051 Aluminum alloy 24S0 sheet	AN—A—12 Condition *A*
14 1/16 × 2	⅝ Douglas fir	AN—F—7
9 1/16 × 4⅝	1/16 phenolic sheet	Navy—17P5, type FBG, Form 3, color natural
——	Make from 73—20137	—— ——
——	Purchased part	—— ——

The entry "Make from (part no.)" is used when the required part can be manufactured from an existing raw casting or forging or when it can be produced by reworking a standard part.

When space does not permit placing the complete description or specification in the area provided, the word "Noted" should be used. Complete data will then appear as a note on the drawing or in the "Remarks" space of the bill of material for drawings having a separate materials list.

Quantity Required and Next Assembly

The quantity entered in the "Required per Assembly" column of the model-requirements block is the amount of the part used on the listed next assembly. The figure entered in the "Required per Unit" column is the *total* required for the complete article. When the part has more than one next assembly, all are listed, together with the quantities required for each. For instance, let us assume that part 207800 is used twice on next assemblies 509000, 507100, and 609101. Assemblies 509000 and 507100 are used twice in the complete article, whereas 609100 is used but once. So the quantities shown in the "Required per Unit" column are four for 509000 and 507100 and two for 609100. The quantity entered in the "Required per Assembly" column is two in each case.

The sum of the requirements per unit for a given model will always be the total quantity of the part required for one complete article. In the preceding example, ten of part 207800 are required for each complete article.

When the part is used on more than one model, the total requirements for each model must appear in the title block. These requirements are entered in an orderly manner, with the requirements for each model being grouped on successive lines of the model requirements space. Thus:

2	2	501234	O—53
2	2	501234—1	
1	2	506785	
3	6	503456	A8—4
2	12	504567	
2	2	509001	
1	4	507101	
Req. per assem.	Req. per unit	Next assem.	Model

The model designation need be shown but once for each group of requirements, as illustrated above, and heavy lines used to separate the groups.

When the part exists both in left- and right-hand opposite forms and both are detailed on the same drawing, with a drawing number suffix used to identify the right-hand opposite version (see Chap. 7), it is necessary to show requirements for both "hands" in the model-requirements space, similar to the following example:

2 LH 2 RH	4 LH 4 RH	601732	L—37
2 LH	2 LH	501234	O—53
2 RH	2 RH	501234—1	
1 LH	2 LH	506785	

Adding Model Requirements on Drawings Used for Several Models

Considerable drafting time can be saved by using parts designed for one model upon another by simply calling out the existing part where needed and then adding model requirements to the drawing of that part.

However, confusion will result if the new model requirements are not immediately added to the drawing. It is the responsibility of the person calling for an existing part on a drawing of another model to either (1) immediately add the new model requirements to the drawing as a change or (2) issue an advance drawing change to add the model requirements. An individual ADC must be written for each drawing affected.

Immediate action to add requirements is important, for it is useless to call out an existing part on a new model unless the drawing of the part involved is changed to add the new model requirements and thus authorize manufacture of the parts required.

Heat-treatment Information

Various methods can be used to specify the desired heat-treatment, but the most practicable scheme is one that specifies the physical condition required in the finished, heat-treated part. When this method is used, a notation similar to one of the following is placed in the title-

block "Heat-treat" space for drawings of *aluminum alloy sheet, rod, or bar* parts requiring heat-treatment:

H.T. TO 17ST	H.T. TO 17STAL	H.T. TO 24ST	H.T. TO 24STAL
(applicable specification)	(applicable specification)	(applicable specification)	(applicable specification)

This assumes, of course, that the parts are to be fabricated from aluminum alloys 17SO, 17SOAL, 24SO, or 24SOAL, as is normally the case.

Drawings of *aluminum alloy forgings or castings* that require heat-treatment should bear a notation similar to the following in the "Heat-treat" space:

H.T. AT SOURCE
(applicable
specification)

All drawing of *steel* parts that require heat-treatment should specify minimum and maximum tensile strength for the finished part, using a tolerance of 20,000 psi. Thus:

H.T. TO 125—145,000 PSI
(applicable specification)

Use of this simple, workable tolerance for production heat-treating avoids listing elaborate specifications and heat-treat process notes.

Springs cold-wound from hardened wire require strain relief after forming, and this should be specified as "Strain Relieve after Forming" in the "Heat-treat" space. Drawings of springs tempered after forming should specify "Spring Temper."

Steel parts requiring surface hardness rather than heat-treatment to improve the tensile strength should specify this requirement in the following manner:

HARDEN BY (method)—DEPTH (as required)
ROCKWELL C (required hardness with 10-point tolerance)
(applicable specification)

When a definite minimum and maximum core strength must be maintained in combination with a hard surface, it is necessary to specify also the core tensile strength, subject to a tolerance of 20,000 psi.

Sometimes it is not desirable to harden the entire surface of a part. When this is the case, the drawing should clearly note the surfaces to be hardened. This practice, however, greatly increases the cost of the part and should be avoided whenever possible.

Scale of Drawings

Drawings are preferably made actual size and should be to scale within $\frac{1}{32}$ in. Dimension figures should be heavily underlined when subsequent drawing changes make them out of scale. Drawings badly out of scale, so that the "picture" is distorted, should be corrected or redrawn.

Enlarged drawings, views, or sections are made when the full or actual size is so small or crowded that the drawing is not clear. Enlarged drawings of detail parts should show (usually in the upper left corner of the drawing) a full-size view of the object, without dimensions and marked "Actual Size." This avoids confusion and permits immediate understanding of the part's relative size.

Reduced-scale drawings are frequently made of large parts that can be clearly shown in a smaller scale, or reduced-scale drawing may be made with actual-size views or sections of complicated portions. All views and sections that differ in scale from the main drawing should be clearly indicated, and the scale for each shown.

All drawings must show the scale in the space provided in the title block. Preferred notations are "Full," "Double," "Half," and "Quarter," or 1/1, 2/1, 1/2, and 1/4. When views and/or sections differing in scale from the main drawing are used, the notation "And Noted" should be added to the scale shown in the title block. The correct scale is then shown under each view and section that differs in scale from the main drawing.

TITLE BLOCK FOR SEPARATE BILL OF MATERIAL

The specimen title block shown in Fig. 8:4 is intended for use with a separate bill of material and is similar to that shown in Fig. 8:3 except for deletion of the materials information space. It should be noted that this block uses a notice of change for each drawing revision and does not provide space for information regarding the nature of the change. Spaces are provided for additional checking and approval signatures, and the drawing title space has been expanded by sacrificing certain minor data shown in the block at Fig. 8:3.

A separate bill of materials is used for each drawing, including all detail drawings. Although this method involves additional printing and distribution during each drawing release, its users claim that this disadvantage is offset by the fact that the accumulated bills of material form a master-parts list for the article without need of additional work. It is always desirable to have a master-parts list for each complete

article (see Chap. 14); and when the bill of materials is an integral part of the drawing, this document must be separately prepared and issued.

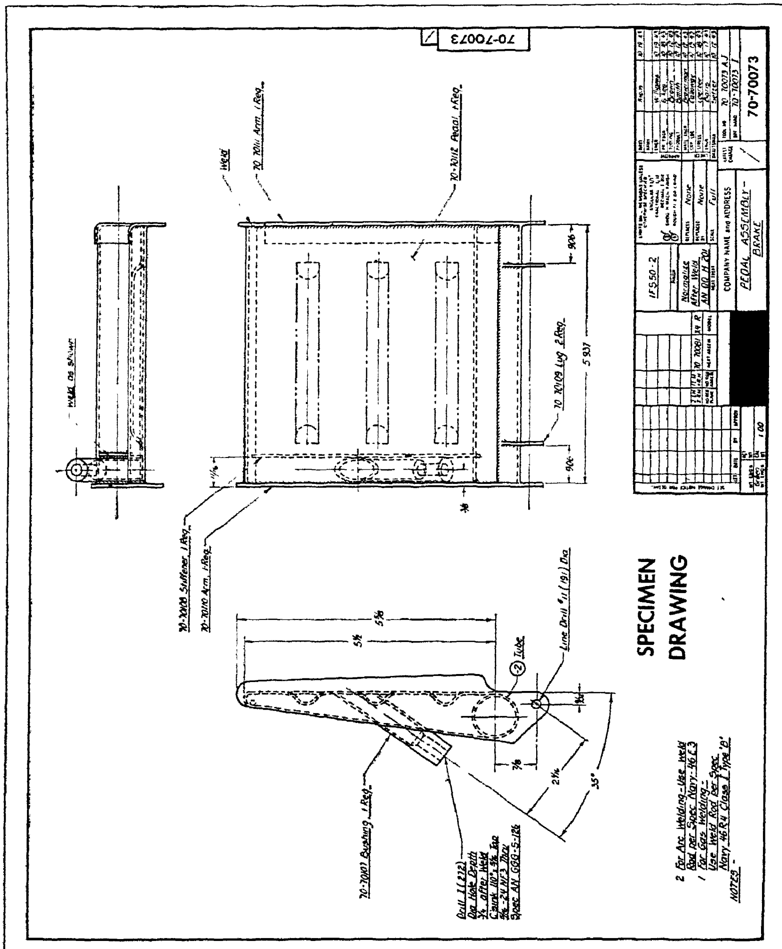


FIG. 8:4.—Drawing title block for use with separate bill-of-material.

BILL OF MATERIAL

The bill of material shown in Fig. 8:5 is printed as 8½- by 11- and 11- by 17-in. forms, on both bond and tracing papers. The draftsman prepares the bill of material on a bond-paper form in longhand. This is forwarded to Release with the drawing. The release group subsequently types the corrected and approved bill of materials on an identi-

cal tracing-paper form, so that it may be printed on the margin of each print, similar to the notice of change.

The bill of material may be changed and reissued without the necessity of changing and reprinting the drawing. When this occurs the drawing and its bill of material will bear different change letters. The bill-of-material change letter is not entered in the "change-letter" space, but the word "Noted" is placed there. The first item under "Remarks" then shows the bill-of-material change letter and the corresponding drawing-change letter. Thus: "D Change B/M—Use with B Change Print."

Separate changes on the bill of material and its corresponding drawing are quite satisfactory when accurately checked and controlled but can cause expensive errors when improperly regulated. For this reason some engineering departments using a separate bill of material handle it as though it were an actual, physical part of the drawing. A change on the bill of material alone then requires a drawing notice of change, with addition of the next change letter to both drawing and bill of material. Conversely, a change on the drawing alone requires addition of the next change letter to the bill of material and reissuance of that document. In this manner, both drawing and bill of material always bear the same change letter.

Entry of a majority of the bill-of-material information is obvious upon inspection, and the following information will clarify items that may appear doubtful:

Date Issued. Filled in by Release when bill of material is released to Blueprint.

Signature Block. Copied by Release from original signatures appearing on bond copy of bill of material.

Next Assembly Block. Identical with data in drawing title block.

Effective On. Enter here the production serial numbers for which the parts are released.

Remarks. Used for necessary comments and data and for B/M change letter when different from that on drawing.

"Replaces" and "Replaced by." Should always be filled in with either the word "None" or the drawing number involved.

Job No. Filled in by Release group.

Line No. Not used.

Part No. Part numbers of component parts of the drawing are listed numerically in the following sequence:

Dash numbers
Company basic drawing numbers
Company standards
Government standards
Vendors numbers and others

If the dash number relates to the drawing being listed, it is sufficient to show the dash number alone. If of another drawing, the complete number must be entered

and in the basic numbers group. A space of one full line should remain blank between each group of parts. The "Part-number" space is divided into two spaces to provide for showing left- and right-hand dash numbers. Always place the left-hand dash number in the upper space. Leave the lower space blank if there is no right-hand dash number.

Part Name. List here the significant portion of the part name. It is not necessary to give the complete name, sufficient to establish only identification.

Requirements. Enter here the quantity required for *one assembly.* The requirements spaces are divided in the same manner as the part-number spaces, to provide for listing individual dash-number requirements for left- and right-hand assemblies. If the assembly does not have a right-hand version, list all requirements in the "LH" column.

Materials. List here the material required for dash-number parts (or for the part shown if B/M is for a detail part) in the manner described elsewhere in this chapter. Do not repeat raw-stock dimensions in the "Size" column.

Zone. Filled in for roll-size drawings to give zone location of each part call-out.

BILL OF MATERIAL

Line No.	Zone	Part Number	Part Name	Req's L.H	Req's R.H	Effective On From	Effective On Through	Material Size	Material Description	Material Spec
		-2	Tube	1	1	707	710	6	1 O D x .035 CM Steel Tube	AN-T-3 Cond A
								—	—	—
		70-70107	Bushing	1	1	707	710	—	—	—
		70-70108	Stiffener	1	1	707	710	—	—	—
		70-70109	Lug	2	2	707	710	—	—	—
		70-70110	Arm	1	1	707	710	—	—	—
		70-70111 70-70111-1	Arm	1	1	707	710	—	—	—
		70-70112 70-70112-1	Pedal	1	1	707	710	—	—	—

SPECIMEN

Date Issued				Model	Next Assembly	Reqs per Unit	Reqs per Assem	Effective On From	Effective On Through	Remarks
10/12/43	Navy	Klein	10/19							
	Army									
	Engr	Williams	10/19							
	Pr Engr	Sikes	10/18							
	Tooling	Brown	10/12							
	Product	Smith	10/12							
	Matl. Engr	Braverman	10/12							
	Gen Loc.	Calloway	10/13	X4-R	70-70081	2RH	1RH	707	710	
	Stress	Coerber	10/18	X4-R	70-70081	2LH	1LH	707	710	Replaces None / Replaced by None
	Check	Baris	10/17	Drawing Title: PEDAL ASSEM. — BRAKE		Page 1 of 1 pages		Job Number 70-163	Change Letter —	Drawing No. 70-70073
	Dftsmn	Setzer	10/12							

FIG. 8:5.—Separate bill-of-material used with title block shown in Fig. 8:4.

The bill of material prepared for a detail part is very similar to that prepared for an assembly. Place the part number (and —1 if applicable) and name on the first line of the form.

CHAPTER 9

DRAWING RELEASE

The function of the release group within an engineering department is to obtain required authorization, checking, corrections, and approval of all drawings before prints are released to the manufacturing departments. After the drawing is processed, prints are obtained and forwarded to the correct destinations. Records maintained by the release group show the status of each drawing and the location of each print.

BASIC DRAWING-RELEASE PROCEDURE

The basic step-by-step operation of the drawing-release procedure is shown in Fig. 9:1. Each completed drawing is given by the draftsman to his group supervisor, who checks new drawings for functional design and changed drawings for correct execution of the change. Drawings meeting with the supervisor's satisfaction are forwarded to the release group for processing through the checking and approval system. Each drawing is recorded and forwarded to the engineering checking group, which checks for (1) production design, (2) accuracy of change incorporation and dimensional exactness, (3) correctness of material and process data, and (4) conformance to drafting standards. Incorrect drawings are returned to the draftsman. When all errors are corrected, each drawing is signed by the checker and returned to Release for forwarding to the special checkers.

These special checkers usually include stress analysts, who examine each drawing to insure that all parts have necessary strength, and weight engineers, who ascertain the weight of each part and make certain that no part is heavier than necessary for the required strength and rigidity. A production engineer may check each drawing to determine the practicability of manufacturing the parts. A tool engineer may examine the drawings to make certain that the design does not require unnecessarily complicated tooling.

The number and variety of special checkers is governed by the nature of the product to meet the needs of the engineering department. Drawings are returned to the release group by each special checker after the required corrections have been made. Release forwards each to the

next special checker and records the location of the drawing in the system.

After final check the drawings are forwarded for engineering approval. This is usually a function of the chief project engineer or chief engineer with new drawings and of the chief draftsman or project engineer with changed drawings. The release group obtains the necessary quantities

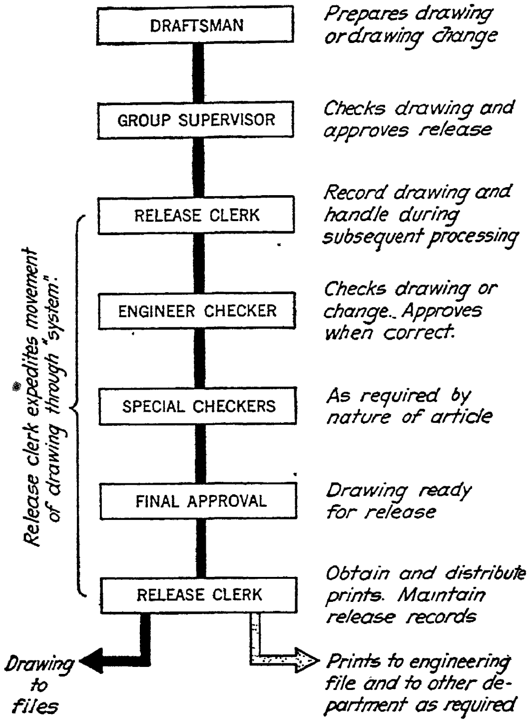


Fig. 9:1.—Flow chart of basic procedure for releasing engineering drawings.

and kinds of prints from each approved drawing, forwards these prints to their destinations, and sends the drawing to engineering files. Records maintained by Release show the destination of each print and the fact that the drawing was released.

TYPES OF DRAWING RELEASE

The release procedure will vary somewhat according to the nature of the drawing. There are three basic functional types of drawings prepared in an engineering department: (1) layout drawings, (2) test drawings, and (3) manufacturing drawings. Layout drawings define basic

structural or mechanical designs and serve as the basis of subsequent manufacturing drawings. Only in rare cases are other than engineering-reference prints made from layout drawings. Because these serve as the basis for future manufacturing drawings, positive control must be maintained to insure that all layout drawings are properly checked, approved, and recorded.

Test drawings are prepared when it is desired to make a mechanism or structure for functional-test, structural-test, or mock-up purposes. The release of these drawings varies only in that the required prints are few in number and should bear special identification in order to preclude the possibility of their use for manufacturing purposes. This can be readily accomplished by prefixing the model designation with *ST*, signifying "special test."

Manufacturing drawings form the large majority of the drawings released by an engineering department. They are prepared to provide manufacturing instructions for parts to be assembled to form complete articles, including production, experimental, spare, and service units but excluding tests and mock-up parts. The detailed release procedure is practically the same, whether the drawing is for experimental or production articles. It is equally important to check and approve both experimental and production drawings. The release of manufacturing drawings will be considered first, as the procedures for releasing layout and test drawings are simply modifications of the basic procedure.

RELEASING MANUFACTURING DRAWINGS

A detail procedure for the release of manufacturing drawings is shown in Fig. 9:2. The method shown is used by a large aircraft company having an engineering department of over 300 employees and simultaneously working on several models. This plan is adaptable to any large engineering department engaged in the design of complex products.

The control of drawing release actually begins before the drawing is prepared, through regulations of drawing numbers. This should be established as a function of the engineering-planning group, who then maintain master numbers books for each model. As soon as a draftsman ascertains the nature of a new drawing, a number is obtained from the numbers clerk in Planning. The numbers clerk determines that the drawing title is correct, assigns the number, and issues to the draftsman the original copy of a "drawing-number assignment" slip similar to that shown in Chap. 7. A duplicate copy of this form is forwarded to the scheduling unit of Planning as notification that work is about to begin on the drawing.

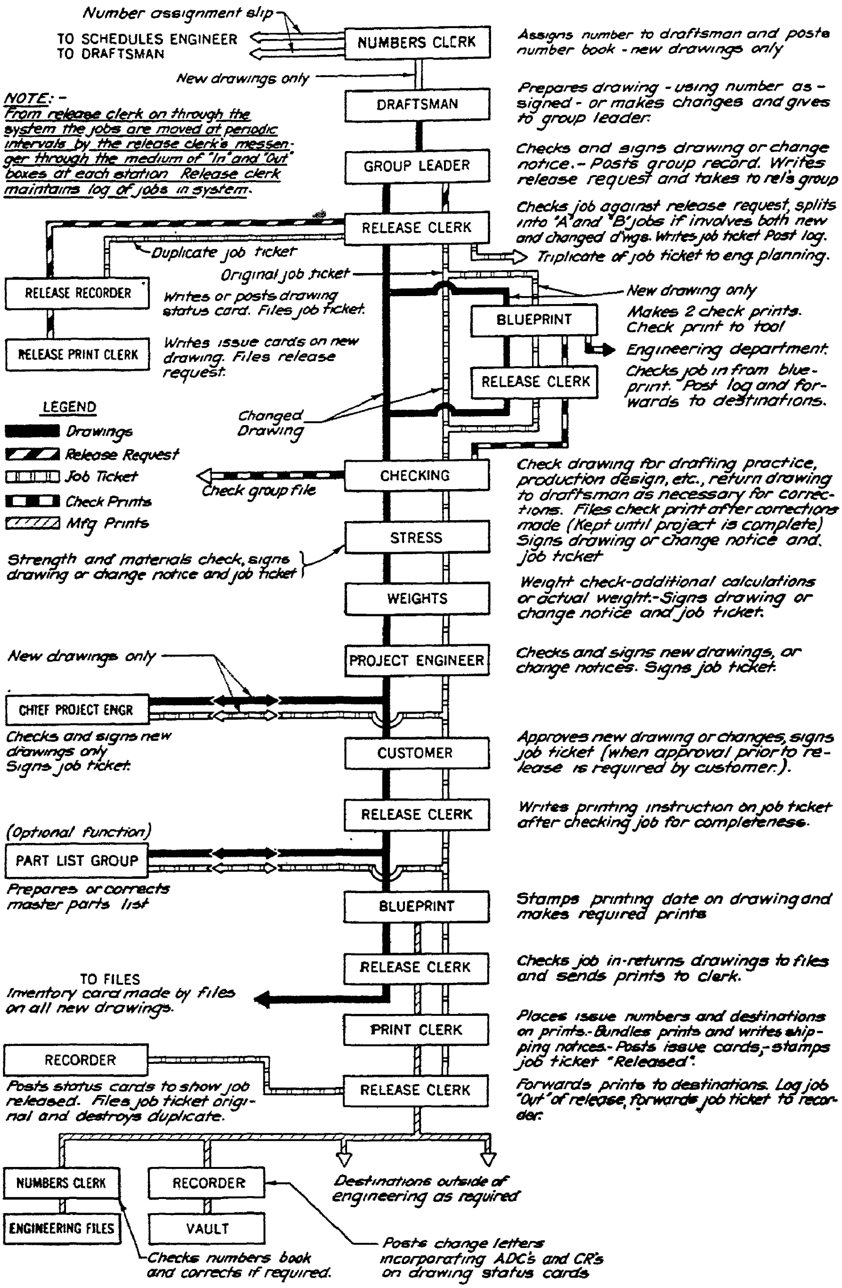


FIG. 9:2.—Drawing-release procedure used by large aircraft factory.

Record of Drawing Numbers

The new drawing number and other pertinent data are posted in the master numbers book for the model affected. This record is kept on a form printed on vellum paper (refer to Chap. 7) to permit daily issuance of revised numbers-book pages to the checking group, production planning department, and others interested in the preparation of new drawings. The numbers book shows the models on which each drawing is effective. It also indicates if the new drawing will replace an existing drawing and notes opposite the existing drawing entry that it will be replaced by the new drawing.

The original copy of the drawing-number assignment slip accompanies the completed drawing to the engineering checking group. The drawing is checked against the slip, and both are checked against the master numbers book, so that drawing number, title, next assembly, and other data are the same as originally authorized by the numbers clerk. Discrepancies are investigated and suitable corrections made in the record.

Group Checking Prior to Release

After the new drawing is completed or the required changes have been made to an existing drawing, it is given by the draftsman to his group supervisor for checking and approval before it is placed in the release system. The group supervisor is responsible for the functional correctness of the design shown on a new drawing and for the correct incorporation of all change data on a changed drawing.

JOB-RELEASE PROCEDURE

Individual drawings are rarely sent through the release system. Instead, groups of related drawings, known as "jobs," are processed and released as units. It is rare that an individual drawing is changed without affecting other drawings. The one changed drawing is of little value to the manufacturing departments unless prints of other affected drawings are received simultaneously.

A single new drawing is also of little value to the manufacturing departments. An assembly without its details cannot be properly planned, nor can materials be ordered. On the other hand, a detail without its next assembly is of little value. The material can be ordered, but assembly planning and tooling cannot be established, and the manufacturing planning must remain partially completed until the assembly print is received.

New drawings are ordinarily released in jobs comprising an assembly and its details. Changed drawings are released in jobs comprising all drawings affected by the change, together with any new drawings involved. If the change is of considerable magnitude, it is likely to be released as several jobs, each comprising a complete group of related drawings. In general, it is good practice to maintain jobs at a maximum of 25 drawings.

DRAWING-RELEASE REQUEST

When a job is ready for release, the group supervisor prepares a drawing-release request, listing the drawings involved. Suitable explanatory remarks and a schedule of reference data forwarded with the job are also shown. These reference data usually comprise layout drawings and copies of all engineering orders, advance drawing changes, and change requests incorporated in the changed drawings. The following information appears on the typical release request shown in Fig. 9:3:

Sheet . . . of . . . Sheets. Indicates the number of pages comprising the complete release request.

Date. When request was prepared.

Model. Model or models that drawings are released for.

Kind of Release. Shows whether regular or rush release is desired.

Approval for Rush. Chief draftsman's approval required for rush releases.

From. Engineering group originating release request.

Effective on. Effective serial number of drawings being released. Drawings effective at different production change points cannot be released in the same job.

Dwg. No. and Breakdown. Marginal indention of the drawing numbers is used to indicate the assembly relationship of the drawings listed.

Name. Only the basic name of each drawing is shown. The word "assembly" or "installation" is added when relevant.

Remarks and Reference Data. Reference data forwarded with the request is listed opposite the relevant drawing numbers. Existing drawings being rereleased without change except for addition of model requirements are noted as "Add model rqmts."

Group Leader. Signature of supervisor of engineering group originating the release request.

Separate release requests are made for the new and changed drawings forming the job, but both requests and all drawings involved are forwarded to the release group as a unit. This is particularly necessary when the routing of new and changed drawings is different, as shown in Fig. 9:2. Segregating the drawings at the source greatly simplifies the release group's work. Engineering departments where the system routing is the same for all drawings should list the entire job on one release request.

Rush Jobs

The release request provides the release group with definite authorization to begin processing the job and also provides a means of approving "rush" jobs. There will be occasions when it is important that one drawing or group of drawings is processed and prints released to the

DRAWING RELEASE REQUEST

Sheet 1 of 1 Sheets
Date: 9 May 45
Model: 70
Kind of Release: Regular
Approval for Rush: —

To: ENGINEERING RELEASE
From: Hydraulics (Group)
Effective on 707 & up

DRAWING No. AND BREAKDOWN	NAME	REMARKS AND REFERENCE DATA
70 - 82 001	Diagram	Picture change (H)
70 - 82 061	Valve Assem.	B chg. (ADC 3021)
70 - 82 463	Sleeve	A chg. (CR 1037)
70 - 82 467	Cap	D change
70 - 82 469	Housing	H change (ADC 2937)

NOTES:
1. List Changed Dwgs. and New Dwgs. on separate requests.
2. Show new Change Letter in Remarks Column.
3. Maximum of one drawing to each line.
4. All ADC's and CR's must accompany drawing.
5. Indicate whether "regular" or "rush" release.

J.R. Graham
Group Leader

Fig. 9:3.—Drawing-release request, prepared when a job is ready for release to manufacturing.

factory as soon as possible. These are handled as rush jobs and given preference over all other jobs in the system. The approval of the chief draftsmen must appear on the release request to authorize a rush job.

RELEASE-GROUP FUNCTIONS

When the release request with related drawings and data is delivered to the release group, the actual processing of the job by the release "system" begins. The work of the release group in handling jobs is divided into three prime functions: (1) recording, (2) dispatching, and (3) print

distribution. All three functions may be done by one person in a small engineering department, whereas a large department will require a chief release clerk with lead personnel in charge of each function.

Each new job delivered to Release is assigned a job number and checked against the release request or requests to ascertain that all listed drawings and reference data are attached.

When the system routing is different for new and changed drawings, jobs comprising both new and changed drawings must be split into two parts. These are identified by *A* and *B* suffixes to the job number. The job number consists of the model designation for the article covered by the drawings, followed by a serial number. For instance, the specimen job ticket shown in Fig. 9:4 covers job 70—163*B*. This indicates that it comprises the changed drawings forming a part of the one hundred sixty-third job relating to model 70.

JOB TICKET

After the job is checked, a job ticket is prepared in triplicate, using the form shown in Fig. 9:4 and listing the following information as applicable:

Job Ticket No. Assigned by release group.

Destination. Filled in by Release on duplicate copies of job ticket accompanying each shipment of prints.

Gen. Description. Title of cost-control serial number (see Appendix I) relating to the job. Only drawings pertaining to a given cost-control serial number (or closely related serial numbers) may be released on the same job. Nonrelated drawings must be released on separate job tickets.

Dwg. No. Number of the drawing to be released.

New. A check is placed here opposite each *new* drawing being released.

Chg. The applicable *change letter* is placed here after each changed drawing being released.

Spec. A check is placed here opposite each existing drawing rereleased for another model without change except for addition of model requirements.

Std. A check is placed here after each *standard-parts* drawing being released.

Dwg. Title. The basic noun (and "assembly" or "installation" if applicable) from the drawing title is shown here.

Next Assembly. Used only for existing drawings rereleased for another model, and checked in the "Spec." column.

Remarks. Used for special information regarding particular drawings.

Release, Check, Stress, Weights, Chief Engineer. The traveler strip containing these headings is signed by the person in charge of each checking and approval station on the original copy, and the same spaces on the duplicate copy are used by Release to record the location of the job, using the odd-numbered lines to record

date "in" at each station and the even-numbered lines for the "out" date. Two blank spaces provide for special routing.

Release for: Model, Effective on. Model and effective production serial numbers that the job is released for are shown here.

DESTINATION (Note: Filled in on copies accompanying print shipments)

JOB TICKET NO. 70-163B

GEN. DESCRIPTION·

ITEM NO	DWG NO	NEW	CH'G	SPEC.	STD.	DRAWING TITLE	NEXT ASSEMBLY	REMARKS
1	70-82001		H			Diagram		Picture change
2	70-82061		B			Valve Assem		Add service data 701 thru 706
3	70-82463		A			Sleeve		
4	70-82467		D			Cap		
5	70-82469		H			Housing		
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								
21								
22								
23								
24								
25								
26								
27								
28								
29								
30								
31								
32								
33								
34								
35								

JOB TICKET No. 70-163 B

RELEASE	CHECK	STRESS	WEIGHTS	CHIEF ENGR.	Customer		RELEASE FOR:
(1) 5/9/45	(3) 5/9/45	(5) 5/10/45	(7) 5/10/45	(9) 5/11/45	(11) 5/12/45	(13)	MODEL 70
(2) 5/12/45	(4) 5/9/45	(6) 5/10/45	(8) 5/11/45	(10) 5/12/45	(12) 5/12/45	(14)	Effective on 707 & up

FIG. 9:4.—Job ticket prepared in triplicate after the job is received by Release group.

The job ticket is an invoice of the drawings forming the job, a traveler to accompany the drawings through the system, a log of the location of the job in the system, a record of the job's checking and approval, and, finally, a notice to those receiving prints when the job is released. Job tickets printed on light-red color paper are used for rush jobs.

The original of the job ticket accompanies the job through the system and is signed by each person checking or approving the job. The duplicate copy is sent to the release recorder for use in posting the drawing-status cards (see Fig. 9:5), and remains in the release "active-job" file while the job is in the system. It is posted to show the dates when the job is delivered to and received from each station in the system. The traveler strip at the lower margin of the job ticket is used for this purpose. The triplicate copy is forwarded to the engineering-planning group, as notification of the drawing's entering the release system.

DRAWING-STATUS RECORD

Prior to actually placing the job in the system, the drawing-status record card for each drawing is posted. A specimen status record card,

HINGE DRAWING STATUS RECORD HINGE

JOB NUMBER	CHG LET	IN DATE	OUT DATE	RELEASED FOR	STOP ORDERS NUMBER	EFFECTIVE ON	ISSUED	RELEASED
12-340	–	1-9-43	2-1-43	701 & up	51	710 & up	4-3-43	4-25-43
12-425	A	3-9-43	3-30-43	" " "				
12-491	B	4-25-43	5-1-43	" " "				

NAME *Panel Assembly – Monocoque Side*

OTHER MODELS RELEASED FOR *73, 74*

DWG NO. *70-27032* LATEST CHANGE BASIC MODEL *70*

NEW DWG	DWG IN SYSTEM	RELEASED	CHANGE	STOP	ADC OR CR	VOID	CANCELED

DWG NO. *70-27032*

ADC RECORD: ADC NUMBER	CHG LET INC	DATE INC	ADC NUMBER	CHG LET INC	DATE INC
253	A	3/30/43			
261	A	3/30/43			
409	B	5/1/43			
476					
492					

CR RECORD: CR NUMBER	CHG LET INC	DATE INC	CR NUMBER	CHG LET INC	DATE INC
1037	B	5/1/43			

EO RECORD: EO NUMBER	EO NUMBER
69	
113	

FIG. 9:5.—Drawing status is recorded on a visible indexing card. Colored signals placed over appropriate squares indicate drawing status.

intended for use with a visible filing system, is shown in Fig. 9:5. This card is the master release record for each drawing, showing each release together with all advance drawing changes and change requests issued

against the drawing. The drawing change incorporating each of these is shown, together with a record of all engineering orders issued against the drawing. Stop orders issued to halt manufacturing are also listed, together with a record of their release.

Advance drawing changes are documents issued to authorize drawing changes in advance of actual change. Their use expedites issuance of change information to the factory. Engineering orders are similar documents that provide engineering authorization for items not requiring a drawing change. For instance, an *EO* should be used to issue special rework instructions for salvaging incorrectly manufactured parts (see Chap. 11).

Each drawing-status record card provides the following up-to-the-minute information, available to all interested parties, for one drawing: (1) drawing number, (2) drawing title, (3) model that card relates to, (4) other models used on, (5) date of original release, (6) date of all changes released, (7) time in system on each release, (8) job number of each release, (9) ADC's outstanding and incorporated, (10) EO's relating to drawing, (11) change requests outstanding and incorporated, and (12) stop orders active and released. The form shown in Fig. 9:5 provides for the following entries:

Face of Form:

Dwg. No. Drawing number that card relates to.

Latest Change. Current change letter on drawing.

Basic Model. Model file in which status card belongs.

New Dwg., Dwg. in System, Released, Change, Stop, ADC or CR, Void, and Canceled. Colored signals placed on appropriate square provide visual indication of drawing status.

Other Models Released for. Here are listed all other models that the drawing has been released for. In the status file for each will be found a duplicate drawing-status record card.

Name. Name of drawing.

Job No. Job number assigned to identify each release of drawing.

Chg. Let. Change letter assigned to drawing at each rerelease on a drawing change.

In Date. Date when job is placed in system.

Out Date. Date when job completes system and is released.

Released for. Effective production serial numbers for which job is released. Same as shown on job ticket.

Stop Orders. The columns under this heading provide for listing the number of each stop order, the production serial number on which the stop is effective, and the dates of its issuance and release.

Back of Form:

Dwg. No. Drawing number that card relates to.

ADC Record. The columns under this heading provide for listing the number of each advance drawing change and the date and drawing-change letter of its incorporation into the drawing.

CR Record. This space lists the number of each approved change request written against the drawing, together with date and drawing-change letter incorporating each into the drawing.

EO Record. This space lists the number of each engineering order issued against the drawing.

Controlling Incorporation of ADC and CR Data

It should be made the responsibility of each draftsman assigned drawing-change work to contact Release and obtain the current status of the drawing before proceeding to work. This information is always available from the drawing's status record. The checking group should contact Release when the drawing is received for checking in order to make certain that all outstanding ADC's and change requests have been incorporated. If an active stop order exists against the drawing, this must be released simultaneously with the drawing change—for a stopped drawing cannot be rereleased.

Visible Drawing-status Record File

Colored signal flags, affixed to the lower margin of each card, give visual indication of the drawing's status. These cards are placed on visible filing boards supported by stands. Thus, all concerned with each model may immediately obtain a mass impression of its progress from the colors displayed on the cards. In some cases it may be found advantageous to use alphabetical signals on the cards to show the latest change letter. The card shown in Fig. 9:5 provides this feature.

The following signals are used on the drawing-status record visible files:

Letter. Indicates current change.

Orange. Indicates drawing number issued.

Pink. New drawing in system (orange signal removed).

Green. Drawing released. Remains until drawing is canceled (pink signal removed).

Yellow. Drawing in system on change (removed when change is released).

Red. Active stop order (removed when stop is released).

Blue. Unincorporated advance drawing change or change request (removed when all are incorporated).

Brown. Drawing void or canceled.

Complete Status File for Each Model

A complete set of drawing-status record cards is maintained for each model. When a drawing is used on more than one model, there is a

status card for the drawing in *each* model file. The space on the card marked "Basic Model" and "Other Models Released for" records the cards existing for each drawing. The "Basic Model" space always shows the model that the file relates to; the "Other Models Released for"

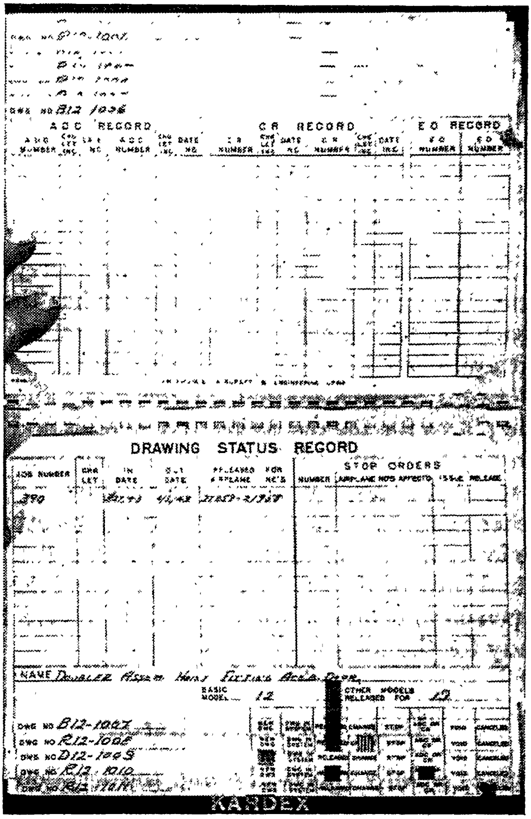


FIG. 9:6.—Status card shown in Fig. 9:5 arranged in Kardex file.

shows the other model files in which cards for the same drawing will be found. When a drawing change is released, it is necessary to post appropriate information on *all* status cards existing for the drawing. The same action is taken when an advance drawing change, engineering order, or change request is issued. The issuance and release of a stop order are shown *only* on the card for the model affected.

This duplication of status cards is necessary, for there must be a complete release record for each model, as the release procedure is for the purpose of controlling the release of data required by the factory

to construct a certain model. Certain drawing changes, advance drawing changes, stop orders, and the like may have different effects upon the various models covered by the drawing—so again a complete status file for each model is imperative. For instance, a stop order may be issued to halt manufacture of a part for one model only, without affecting its use on several other models.

Should it be found undesirable to use a visible file for the drawing-status record cards, the identical card can be rearranged for use in a box file. It is necessary only to move the record strip from the bottom of the card to the upper margin and place the signals along the top of each card.

HANDLING OF JOBS

Jobs placed in the system cannot be expected to carry on under their own momentum. Instead, the release dispatcher has the responsibility of delivering each job to the next station in the system, picking up all completed and approved jobs and personally forwarding these to the next station. Boxes at each station for incoming and outgoing jobs provide specific places for the dispatcher's deliveries and pickups. The dispatcher also has the responsibility of expediting jobs that appear to lag by urging speedier action by the station at fault.

The dispatcher records the location of each job, using the traveler strip along the lower margin of the duplicate job ticket in the active-job file. The original copy of the job ticket is signed and dated in the same spaces by the person in charge of each station as soon as the job is completed and ready for the dispatcher.

Daily Job-status Report

Release prepares a daily report showing the location of each job in the system, together with notation of jobs that appear unduly delayed. Copies are forwarded to Engineering Planning, the chief clerk, and the chief draftsman. The necessary corrective action is taken by the chief draftsman or chief clerk, depending upon the station at fault. Planning is thus constantly advised of each drawing's progress and assists in cases where delay is caused by lack of personnel at a particular station.

RELEASING THE JOB

Upon receiving the customer's approval, the job has completed the system and is ready for release. At this time the *A* and *B* portions of a job split because of it containing both new and changed drawings are

collected to form one job. In some cases the complete, approved job must be routed to the parts-list group prior to actual release. This is desirable when a master-parts list (refer to Chap. 14) is maintained for each model or article, and copies are distributed throughout the factory. In such cases the master-parts list is the only authentic record of active drawings and should be revised and reissued concurrently with the daily release of jobs.

Every station added to the release system increases the time required to process a job, and it may be advantageous to eliminate the parts-list group from the system. If so, prints of each job should be forwarded directly to the parts-list group by Release, as authority to make appropriate corrections to the master-parts list.

Ordering Prints

When the completed job is received, the release clerk checks to ascertain that it contains all drawings shown on the job ticket and then prepares instructions regarding the quantity and kind of prints required. This information is entered in the space provided at the upper margin of the job ticket. The job is then forwarded to the blueprint unit for preparation of the necessary prints. Prior to sending the job to Blueprint the release clerk removes all reference data and returns these to the proper files.

Blueprint stamps the printing date on each tracing, opposite the appropriate change letter in the alteration block, and makes the required prints. Placing the printing date on the tracing eliminates entering the date on each print. The drawings, job ticket, and prints are then returned to Release.

The release clerk checks the job in, returns the drawings to the engineering file, and forwards the prints to the print clerk. Each print is marked with its issue number and destination to provide positive individual identity, and the print-issue record cards are posted (refer to Chap. 10). The prints are then gathered in bundles for each destination. A shipping notice is prepared in duplicate for each bundle, and the original copy of the shipping notice is delivered with the prints. The duplicate is signed by the recipient and retained by Release as proof of delivery.

When prints are delivered, the job ticket is stamped "Released" and forwarded to the release recorder. The recorder posts the affected drawing-status cards to show that the job is released. The duplicate job ticket is removed from the "active-job" file and destroyed, and the original job ticket is placed in the "closed-job" file.

A copy of the job ticket is forwarded to each destination with the prints forming the job. This gives information on the general nature of the job and its relationship to the model or article affected. These additional copies are prepared just prior to release of the job in order to avoid errors caused by possible changes in the nature of the job during its course through the system.

The prints intended for the engineering files are routed to the numbers clerk prior to delivery to the files. This permits the numbers clerk to check the prints against the numbers books and to make appropriate corrections or entries in the books.

Vault-copy Prints

One print of each drawing release is designated as a "vault copy" and is intended for a master file, in which is maintained one print of every change on each drawing. This vault-copy print is first routed to the release recorder for posting the incorporated advance drawing changes and change requests on the drawing-status cards. This information appears on the notice of change (see Chap. 12) attached to each changed drawing.

RELEASE OF CONFIDENTIAL DRAWINGS

Certain articles or models may be classified as "confidential" or "secret," and special treatment is required for major assembly drawings revealing the nature and purpose of the design. Detail parts and subassemblies rarely reveal any significant data and may usually be handled in the same manner as unclassified drawings.

It is the responsibility of the project engineer (chief engineer in small department) to determine which drawings are to be classified as confidential or secret. These drawings are plainly marked with the appropriate security classification, and prints are not issued as part of a regular job release, except that a "vault-copy" print is made. The release group, instead, notifies all normal recipients of prints when a classified drawing clears the system, and those who require prints may request special-issue prints. The issuance of prints of classified drawings needs specific approval of an engineering executive.

DRAWING RELEASE IN A SMALL ENGINEERING DEPARTMENT

In a small company, where the engineering department is correspondingly small, it is feasible to use a greatly simplified release procedure. This is founded upon three basic premises: (1) that the average ability

of engineering personnel will be higher, with correspondingly fewer drawing errors, (2) that the effect of errors will be less costly, owing to the smaller number of parts manufactured upon each drawing release, and (3) that the greater flexibility possible with a small organization will permit immediate correction of errors upon notification by the manufacturing departments.

Drawings completed by the engineering department are forwarded to the release group with a release request marked either "Experimental" or "Production" in the space provided for indicating the kind of release desired. This release request also serves as a job ticket when the job number is placed in the upper right corner and the project engineer's or chief engineer's signature is obtained in the lower margin as authority for release.

These releases are handled on the basis that all necessary checking has been accomplished prior to release and are printed and distributed without passing through the engineering checking and approval procedure described in preceding paragraphs.

Experimental Release

All prints on an experimental release should be stamped "Experimental," in addition to other stamping. An arrangement must be made with the experimental department to notify the engineering department by change requests of all changes necessary to correct the experimental drawings for production. Once these changes are incorporated, the drawings can be forwarded to the release group for a production release.

Production Release

Production prints should be stamped "OK for Production," in addition to other stamping. Experimental drawings rereleased without change for production should be assigned the next change letter for record purposes. A notice of change is not necessary, and "Reld for Prod—No Change" is entered in the alternation block.

All prints must bear issue numbers and should be forwarded to their destinations with a shipping notice in duplicate.

RELEASE OF LAYOUT DRAWINGS

All layout drawings intended as the basis for engineering work must be assigned a number, carry the standard title block, and be approved and released before manufacturing drawings are prepared. The project

engineer should determine which layouts require checking prior to release. The relevant layout is referenced on all manufacturing drawings, by placing "Ref Layout (*number*)" adjacent to the drawing title block and must accompany the manufacturing drawings through the release system.

The group supervisor is responsible for obtaining the following approval signatures on each layout before its removal from the drafting board:

Structures supervisor
Weights supervisor
Materials engineer
Project engineer
Note: The project engineer will note either "Check" or "No Check," followed by his signature, in the margin below the title block.
Chief engineer

These signatures indicate preliminary approval, and final approval is obtained by signatures on the manufacturing drawings prepared from the layout.

The engineering planning group should notify the structures supervisor, weights supervisor, and materials engineer of all new layout numbers issued in order to keep them constantly informed of all layout work in process. It then becomes their responsibility to follow up and check each layout as it progresses.

The materials engineer places the AEMO number (see Chap. 13), covering the layout in the margin, opposite his signature. Following the chief engineer's approval, the layout is sent to the release group. Release records the layout and forwards as follows:

a. Layouts requiring checking are forwarded to the checking group on a "Rush" job ticket. Following completion of checking and corrections the layout is forwarded to the blueprint unit for four prints: one "Vault Copy," two "Engr File" copies, and one "Tool Design" copy. Blueprint returns the layout to engineering files for recording and filing.

b. Layouts that do *not* require checking are forwarded by Release directly to Blueprint for preparation of the required four copies. Changes found necessary by the checking group must be approved by the project engineer before release of the layout.

Layout Changes

All changes necessary to keep layout drawings up to date should be promptly made, and the layout rereleased on a change letter, with approval of the notice of change obtained in the manner used to approve

the original layout. The information on the layout should agree at all times with the current manufacturing drawings. Service data may be required on the layout to show the effective serial number of basic changes.

Loan of Layouts from Engineering Files

A layout drawing may be borrowed from engineering files in the same manner as any other drawing (see Chap. 10). The layout should be returned as soon as possible and must not be considered as "belonging" to any one design group.

Layout Must Accompany Drawings in System

All manufacturing drawing detailed from a layout (or referring to a layout) must be accompanied by the layout when forwarded to the release group for placing in the system.

RELEASE OF TEST AND MOCK-UP DRAWINGS

Whenever it is desired to release a drawing for structural test, functional test, or mock-up, a procedure must be followed that will avoid the drawing being accidentally released for manufacture of production parts, and this is accomplished by calling for "special-test" model requirements on the drawing.

A drawing released for test or mock-up purposes only will carry the model designation *ST* suffixed with the model number (thus: *ST*—10 or *ST*—34) in the "Model" space of the title block. An engineering order is issued at the time when the part is released for test, detailing the nature of the work to be accomplished.

Unless other instructions are issued by the chief engineer, the drawing should be released for production immediately after incorporation of all changes found necessary during fabrication and testing of the test part. It is the project engineer's responsibility to follow the progress of all engineering and shop work on test parts and to expedite their release for production.

When the drawing is rereleased for production, the correct model designation is *added*, and the drawing released on a change. The notice of change records all changes from the original test part to the final manufactured part and indicates the effective serial number of the part as obtained from the manufacturing planning department.

Layout drawings are not released for test or other manufacturing purposes and are used only for design reference. The established routing

for the model affected will be followed by the release group in handling test and mock-up drawings. The manufacturing-planning department will not take action on test and mock-up releases until an engineering order detailing the work to be accomplished is received.

DRAWING RELEASE FOR MAINTENANCE ENGINEERING

The system of drawing release described in the preceding paragraphs is predicated upon operation of a product-design engineering department engaged in preparing drawings for the production of manufactured articles. Another type of engineering department is primarily occupied by the maintenance of factory and fleet equipment. This is often referred to as "maintenance engineering," and is encountered in processing plants and transportation enterprises.

Each drawing release issued from a maintenance engineering department usually relates to specified equipment rather than to a block of production units. This requires a modified release-notice to insure that complete information reaches all parties concerned with the work to be accomplished.

In such cases the Job Ticket should be replaced by a detailed Release Notice, similar to the example shown in Fig. 9:7. This is prepared as an 8-½ by 11-in. form on tracing paper to permit reproduction of copies by blueprinting. A copy of the release-notice accompanies each set of prints comprising the engineering release. Additional copies are forwarded to various supervisors affected by the release of engineering information.

It is necessary that maintenance engineering receive definite notification of the accomplishment of each engineering release, so that drawings, part lists, spare-parts requirements, and other records may always reflect the actual status of company equipment. Releases affecting several equipment units, perhaps widely scattered over an extensive transportation system, may not be simultaneously accomplished, and engineering should receive individual notification of accomplishment of the authorized work on each unit. This can be done by using a "Completed Engineering Release Report," similar to the example shown in Fig. 9:8.

One copy of the completion notice is prepared for each equipment unit affected by the engineering release and accompanies the set of prints released to the maintenance shop. As the required work is accomplished on each unit, the corresponding notice is filled in by the shop foreman and inspector responsible for its accomplishment and is returned to the

engineering department. Engineering then corrects all records to show accomplishment of the work. Completed reports issued for releases that must be accomplished as soon as possible are printed on red paper

WESTERN AIR LINES, INC

ENGINEERING RELEASE

ENG RELEASE NO
SUPPLEMENTS RELEASE NO
SUPERSEDES RELEASE NO
ENGINEERING REQUEST NO
DATE AUTHORIZED
DATE RELEASED

This Copy To	Dwgs Etc To		This Copy To	Dwgs Etc To	
		VICE PRES OPERATIONS			CHIEF INSPECTOR
		CHIEF PILOT			TRAFFIC DEPT
		DIRECTOR OF MAINT			TREAS DEPT
		SUP OVERHAUL			CAA
		COMMUNICATIONS			MANUFACTURER
		SUP OF SERVICE			ENGR DEPT FILE

TYPE OF RELEASE			
PRIORITY		ROUTINE	
CAA		PROPOSAL	
CAA FORM 337 REQUIRED			
MAINT MANUAL REV REQ			
OPER MANUAL REV REQ			
FABRICATE		REMOVAL	
INSTALL		TEST	
REPAIR		CANCELLATION OR CORRECTION	
CHANGE			
PROJECT NO			

EFFECTIVE ON

MODEL REFERENCE

DESCRIPTION.

REMARKS:

The Following Drawings, Sketches, Reports, Specifications Applying (are) Attached (are not)

SERVICE TEST PERIOD DATE.

EST WEIGHT	INCREASE	+ LBS AT IN
	DECREASE	− LBS AT IN.

REQUESTED BY
DATE
DEPT

APPROVED	Eng	Dir of Maint	CAA	Dir of Eng	Release

Form En - 14

FIG. 9:7.—Engineering release notice replaces Job Ticket for maintenance-engineering releases.

and bear the notation "Red is priority." Green paper and the notation "Green is routine" are used for jobs that can be accomplished at the maintenance department's convenience.

WESTERN AIR LINES, INC

COMPLETED ENGINEERING RELEASE REPORT

PROJECT NO ______________

STATION ______________

RED
IS
PRIORITY

AIRPLANE NC ______________

WAL NO ______________

ENGINEERING RELEASE NO ______________

DESCRIPTION.—______________

HAS BEEN COMPLETED AT THIS STATION ON THE ABOVE ENGINE ☐ AIRPLANE ☐ ACCESSORY ☐

CHANGE MADE BY ______________, MECHANIC, DATE ______________

INSPECTED BY ______________, INSPECTOR, DATE ______________

APPROVED BY ______________, FOREMAN, DATE ______________

REMARKS. ______________

WEIGHT CHANGE

ITEM	DESCRIPTION	WEIGHT ADDED	WEIGHT REMOVED
1			
2			
3			
4			

THIS SECTION FOR COMPLETION BY ENGINEERING OFFICE

CAA FORM 337 SUBMITTED ______________ DATE ______________ CAA DIRECTIVE ______________

MFGR'S SERVICE BULLETIN NO ______________ OTHER ______________

POSTED BY ______________ 1 ENG RELEASE RECORD ☐ 2 WEIGHT AND BALANCE RECORD ☐

3 MFGR'S SERVICE BULLETIN RECORD ☐ 4 PROJECT RECORD ☐ 5 OTHER ______________

Form En - 15

FIG. 9:8.—Completed engineering release report notifies engineering upon completion of maintenance work authorized by Release.

ARRANGING THE OFFICE FOR EFFICIENT RELEASE

The drawing-release system necessary for a large engineering department involved in the design of complex products requires considerable handling and movement of drawings. The arrangement of the various groups concerned with drawing release should provide for minimum transportation of jobs. This can be accomplished by plotting the path of jobs on a floor plan of the engineering department and arranging the groups involved in the drawing release so as to obtain minimum travel distances.

The most efficient routing plan for drawing release will provide (1) straight-line movement of jobs, not only through the department as a whole but also through each group involved in the system; (2) successive stations in the system placed as near to each other as possible; and (3) a circular travel pattern since the job must eventually return to its point of origin in the release group.

OTHER METHODS OF RELEASING DRAWINGS

There are other methods of releasing drawings besides the basic system described here, but the procedure outlined in this chapter has been found to be most practical in some of the largest engineering departments. It is also used in many small engineering departments and is probably the most effective and efficient of all. Discussion of other systems would serve little useful purpose and result only in confusing the issue.

Well-regulated engineering offices may, however, find it advantageous to eliminate re-releasing drawings to add only model requirements. This can be done through information listed on the job ticket. The expense of new blueprints to supply manufacturing departments with a listing of the latest model requirements is eliminated. This should be considered *only* when excellent control is present in the engineering and manufacturing-planning departments.

In this case the job ticket form (see Fig. 9:4) is modified by addition of "Required per Assembly" and "Required per Unit" columns, placed adjacent to the "Next Assembly" column.

Existing drawings being re-released without change except for addition of model requirements are grouped on the Release Request, and noted as "Add model rqmts." Requirements per assembly and unit and the next assembly are shown for each of these drawings, similar to the manner in which these data would appear in the drawing title block. Release transfers these data to the job ticket, checking each drawing in the

"Special" column, followed by removing the affected tracings from files and adding the new requirements data. These drawings do not accompany the job through the system but are returned to files after addition of requirements. Prints of these drawings are not issued when the job is released.

The manufacturing-planning department releases the parts for manufacture upon receipt of the job ticket showing added model requirements. Prints bearing the added model requirements do not reach the files until the drawings are changed and reissued for reasons other than model requirement addition.

SUMMARY OF DRAWING-RELEASE PROCEDURE

The general procedure recommended for the release of engineering drawing can be briefed as follows:

a. Draftsman gives completed drawing to group supervisor.

b. Group supervisor prepares release request (showing type of release, and incorporating breakdown if several drawings are involved), and gives drawing or drawings (now termed a "job") to the release group.

c. Release checks the job for completeness, prepares required copies of job tickets, and assigns job number.

(1) Original job ticket sent with drawings to checking group (check prints are furnished with new drawings only).
(2) Duplicate job tickets retained by Release as record of job.
(3) Additional copy of job ticket forwarded to Engineering Planning

d. Release prepares drawing-status card for new drawing or posts existing card for changed drawing.

e. Original job ticket accompanies job through all stations in the system and is signed by all parties checking or approving the job.

f. Upon completing the system, original job ticket and drawings are forwarded to Blueprint to make release prints. Quantities and kind of prints required are noted on job ticket by Release.

g. Blueprint, upon printing the release, returns all drawings and prints to Release.

h. Issue numbers are placed upon each print; the issue record cards posted accordingly; and the reproductions dispatched to their destinations to complete the release.

i. Two copies of a shipping notice accompany each shipment of prints. One copy of the shipping notice is signed and returned to Release as acknowledgment of delivery.

CHAPTER 10

DRAWING AND PRINT CONTROL

NEED FOR DRAWING AND PRINT CONTROL

The drawings prepared in the engineering department are the most valuable articles in the possession of a company for they serve as the basis for everything accomplished by the entire organization. All other departments in the company are engaged in manufacturing, selling, and servicing the articles described by the engineering drawings, and safeguarding these drawings from damage or loss is a vital factor in the success of the company.

When a company is engaged in the manufacture of articles for government use, the safeguarding of drawings takes on additional importance for they are usually assigned a security classification of restricted, confidential, or secret, depending upon the nature of the article manufactured. In these cases the regulations governing the security of classified data make mandatory the establishment of a dependable system for drawing and print control.

The prints produced from each drawing have a value far greater than the printing cost, and their control deserves the same attention given the original drawings. Prints of drawings are normally used for (1) engineering reference, (2) manufacturing, and (3) sales. Random, unrecorded distribution of prints precludes the possibility of replacing obsolete prints and introduces the hazard of working with obsolete information with resultant costly errors. Furthermore, considerable time may be unnecessarily spent in locating misplaced prints.

The methods established for maintaining control of each drawing and every print will vary with the size of the engineering department, but in each case they must provide a complete, practicable method of regulating the (1) handling and filing of drawings and (2) ordering, issuance, and recall of prints. The *basic* methods described here, however, are applicable to any engineering department, regardless of size. In a small engineering department it may be the part-time responsibility of a junior draftsman to maintain the necessary records and files. A larger department will have a clerk specifically assigned to this work, whereas the files group of an extensive engineering department will employ several persons.

TERMS RELATING TO DRAWING AND PRINT CONTROL

The explanation of a comprehensive system of drawing and print control involves the introduction of special terminology, which in many cases is arbitrarily established as being descriptive of the condition, operation, or item described. The terms are listed at this point in order to avoid the necessity of frequent repetition in the paragraphs following.

a. Drawing. The original tracing, whether upon cloth or vellum, with pencil or ink, drawn to show manufacturing or design information. Also applicable to duplicate tracings that have been altered to show a modified design and thus become the basic drawing for another part.

b. Print. A copy of a drawing, regardless of the method of reproduction.

c. Blueprint Unit. The activity within the engineering department that prepares prints of drawings, irrespective of whether blueprints or direct-line prints are produced.

d. Regular-release Prints. The normal distribution of prints for each new or changed drawing prepared in the engineering department and distributed to all print files within the company as the concluding phase of drawing release.

e. Special-issue Prints. Prints made in addition to the regular-release prints and at the individual request of company employees for the purposes of reference, tracing, or duplicate tracings to be altered and become "new" drawings.

f. Other-company Prints. Prints obtained from other companies and maintained in the engineering department for reference.

g. Other-company Drawings. Duplicate tracings obtained from other companies and maintained in the engineering department for the production of reference prints.

DRAWING FILES

Every engineering department, regardless of size, must have suitable files for storing original drawings and reference prints. Drawing files are commercially obtainable in the form of cabinets with shallow drawers for the *flat* filing of drawings up to the 22- by 34-in. size and the *roll* filing of drawings up to 42 in. wide. Refer to Chap. 8 for information on standard drawing sizes.

All flat-filed drawings of a given size should be placed in one drawer or group of drawers. The indiscriminate storing of various sizes in a single drawer renders the location of a particular drawing much more difficult since it is only too easy for a small drawing to become "lost" between two large drawings. Each file of drawings of a given size should be arranged in numerical sequence, despite the fact that many numbers will be omitted because they are located in the file drawer for another size.

All roll-size drawings should also be filed numerically in one drawer or group of drawers and placed side-by-side to extend the depth of the drawer. There are other methods of filing roll-size drawings, including

the use of bins, racks, or paper tubes, but none of these provides the ease of filing possible with drawing cabinets.

The file for void and canceled drawings should be separate from that for active drawings. Because these drawings are seldom withdrawn, it is practicable to use a "dead-storage" file in the form of a rack holding a quantity of large filing tubes, each identified by a number or letter. A quantity of void and canceled drawings can be filed in each tube, with their respective inventory cards being marked to indicate the proper filing tube as well as the status of each drawing.

FIG. 10:1.—Drawing and print file in typical engineering department. (*Courtesy Ryan Aeronautical Co.*)

Drawing files should be located within a fireproof vault, or fire-resistant filing cases should be used. If circumstances make it impossible to use either method for protecting the drawings, then a "vault-copy" print should be made for each drawing release, including all changes, and filed in a fireproof storage vault remote from the company premises. In the event that the original drawing is lost, a duplicate tracing can be made from the vault-copy print for temporary use and a new tracing prepared when time permits. Furthermore, this complete file of vault-copy prints will often be of value in determining the proper replacements when orders are received for spare parts relating to an early model.

PRINT FILES

Prints should always be folded to a size approximating 8½ by 11 in. and filed in numerical sequence in standard letter-size four-drawer filing cabinets. The drawing title block containing the drawing number will

usually appear in the lower, right-side corner of the folded print. The prints should be filed upside down in order to bring the number to the top and toward the *back* of the file. The fact that the numbers are inverted is of no consequence since the eye level will be above the file, with the result that the number may be read with ease when the prints are thumbed back. This arrangement eliminates the use of clumsy, space-consuming file folders or numerical dividers and is successfully used in some of the largest engineering departments. However, if the drawing number is repeated in the *upper*, right-hand portion of the folded print, as explained in Chap. 8, the prints need not be inverted when filed.

ENGINEERING DEPARTMENT SUPPLIES

The engineering files should serve as a distribution point for all drawing supplies used in the engineering department. A table for cutting lengths of cloth or vellum to the desired length should be provided.

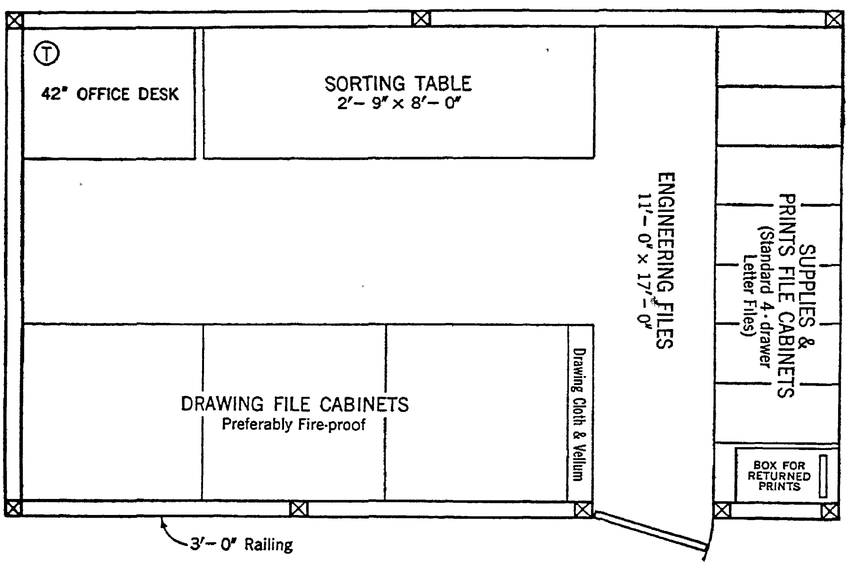


FIG. 10:2.—Floor plan for engineering print files.

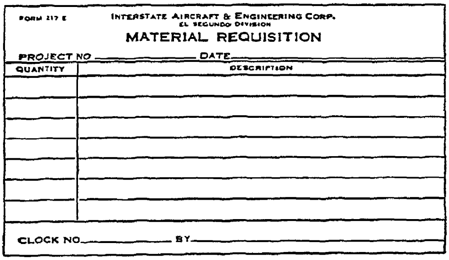
The files arrangement should be one that discourages unauthorized entry to the files area and requires engineering personnel to request all drawings, prints, and materials from a file clerk rather than to serve themselves. That the engineering personnel obtain all drawings and prints from a designated person or persons is the essence of drawing and print control.

The arrangement of the engineering files should provide an enclosed area with adequate work space and a large sorting table for arranging the returned prints prior to refiling. The floor plan of a files area suitable for a small engineering department of approximately 75 employees is shown in Fig. 10:2. This plan purposely omits a service counter, and all business must be transacted *over the top* of the filing cabinets that form one wall of the enclosure. The absence of a convenient counter to lean upon and search prints for imaginary information discourages employees from idling away time at the files.

A box or bin for returned prints is an essential part of the files arrangement. This should be the postbox type where returned prints are dropped through a slot in order to discourage unrecorded "borrowing" of prints.

MATERIALS REQUISITION

In a large engineering department, where the daily consumption of supplies becomes an important cost item, it may be advisable to use a materials-requisition form (similar to that shown in Fig. 10:3) for all


FORM 217 E

INTERSTATE AIRCRAFT & ENGINEERING CORP.
EL SEGUNDO DIVISION

MATERIAL REQUISITION

PROJECT NO ____________ DATE ____________

QUANTITY	DESCRIPTION

CLOCK NO ____________ BY ____________

FIG. 10:3.—Material requisition used to obtain supplies at engineering files.

materials issued by the files. The time spent preparing these requisitions is compensated for by the elimination of waste because the existence of a record for every item issued discourages the tendency to obtain more supplies than are actually needed.

The cumulative posting of the information furnished by these requisitions provides an accurate basis for forecasting supply requirements and is invaluable when long-range estimates of material requirements are to be made. The form shown in Fig. 10:3 is self-explanatory, and pads of these are provided at the engineering files. These are filled out with the required information and given to a file clerk, who fills the order and files the requisition. Questionable orders are referred to the files supervisor.

FILE CLERK

One person in the engineering department must be appointed engineering file clerk and made responsible for maintaining accurate records and complete files of all drawings and prints. As the size of the department increases, it will be necessary to employ additional file clerks, and the most experienced and responsible of these should become engineering-files group leader.

Personnel should not be assigned to the engineering files if their experience qualifies them for higher paid positions. Only by assigning capable clerical personnel to the files on a permanent basis can drawing and print control be accomplished in an efficient manner. Only when files personnel know that their employment depends upon the satisfactory filing and recording of engineering drawings and prints can the files group be expected to operate efficiently. When file clerks consider their stay in the files as being a brief steppingstone to another job, there may be a tendency to do only that which is necessary to "get by" while awaiting the next step in their progress through the engineering department toward the ultimate goal of becoming chief engineer.

DRAWING-INVENTORY RECORD

All drawings should be forwarded to the engineering files for indexing and filing immediately after being printed for their initial release. This should be established as a responsibility of the engineering release group. The only exception to the rule should be drawings originating in other departments of the company, and these are normally returned to the originating department with the prints.

The engineering files should maintain a perpetual inventory of all drawings through the medium of an inventory-record card similar to that shown in Fig. 10:4. An inventory card is prepared for each drawing immediately upon its original delivery to the files and remains as a permanent record of the drawing. The card in Fig. 10:4 lists the following information, obtained principally for the drawing's title block:

Size. Code letter or number designating the drawing size.

Kind. Nature of the drawing: whether cloth or vellum, direct-line transparent, vandyke, or phototracing. Code letters, such as *C*, *V*, *O*, *V/D*, and *P* can be used.

Dwg. No. Number appearing in drawing title block.

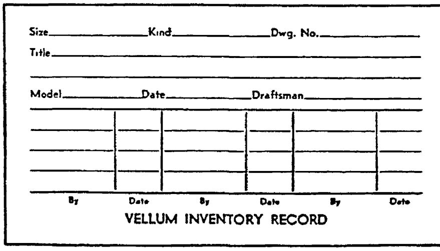
Title. Exact title appearing upon drawing.

Model. Model or models that drawing is released for.

Date. Date when drawing was made.

Draftsman. Name of draftsman who made the drawing.

By and Date Columns. The columns in the lower portion of the card are the inventory record and are repeated on the back of the card. Clerk preparing card initials and dates the first of these spaces. The additional spaces are used at periodic inventories.


Size ____ Kind ____ Dwg. No. ____
Title ____
Model ____ Date ____ Draftsman ____

By	Date	By	Date	By	Date

VELLUM INVENTORY RECORD

FIG. 10:4.—Drawing-inventory record card.

DRAWING CHARGE-OUT SYSTEM

Drawings should be loaned by the files only for the purposes of (1) drawing change or (2) printing. Each loan should be recorded on a drawing charge-out record card similar to that shown in Fig. 10:5, authorized by an engineering supervisor and countersigned by the person receiving the drawing. These charge-out cards are filed in the drawing-inventory record file immediately in *front* of the inventory card for the loaned drawing and should be printed on paper of a contrasting color.

It may become necessary to loan a drawing for a purpose other than drawing change or printing. Sometimes a drawing must be loaned for reference when an engineering file print is not available. This condition should not be encouraged, however, and drawing loans of this nature should require the chief draftsman's authorization.

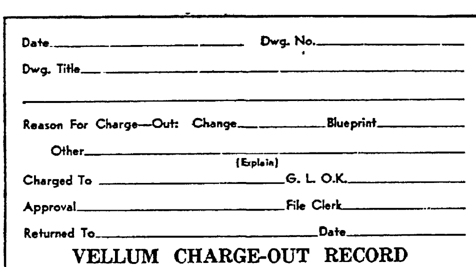

Date ____ Dwg. No. ____
Dwg. Title ____
Reason For Charge—Out: Change ____ Blueprint ____
Other ____
(Explain)
Charged To ____ G. L. O.K. ____
Approval ____ File Clerk ____
Returned To ____ Date ____
VELLUM CHARGE-OUT RECORD

FIG. 10:5.—Drawing charge-out card for record of loaned drawings.

The drawing charge-out record shown in Fig. 10:5 lists the following information:

Date. When loan was made.
Dwg. No. Number of drawing loaned.

Dwg. Title. Title of drawing loaned.
Reason for Charge-out. The appropriate space is checked, or a detailed reason shown on line marked "Other."
Charged to. Signature of borrower.
G. L. OK. Signature of an engineering supervisor authorized to approve drawing loans.
Approval. Used only when loan is for a purpose other than change or printing. Chief draftsman's signature required.
File Clerk. Initials of clerk making loan.
Returned to. Initials of file clerk receiving returned drawing, and date of return.

The charge-out card remains in the inventory file until the drawing is returned. The card is then returned to the borrower.

Drawings should not be removed from the engineering department, except when sent to a commercial blueprint firm for prints, and these transactions are handled through the release group. Adherence to this procedure will simplify the location of misplaced drawings by isolating their location to the boundaries of the engineering department.

DRAWING-INVENTORY CONTROL

At periodic intervals it is desirable to recall all drawings to the engineering files for an inventory. The inventory-record and drawing charge-out cards are used for this purpose. Each drawing shown as loaned by a charge-out card is recalled. A check is then made to verify the fact that every drawing listed on the inventory cards is actually in the files. The interval between inventories should not exceed six months.

Usually there will be several drawings that cannot be located during the inventory. The record will show them charged to certain individuals, but the borrowers will be unable to locate the drawings. This condition is generally due to the original borrowers loaning the drawing to another person or to the appropriation of the drawing by another draftsman without the knowledge of the original borrower.

The number of misplaced drawings can be minimized by establishing a definite rule that the person borrowing a drawing is responsible for its safekeeping until it is returned and must not loan the drawing to another person. Such a rule can be enforced by deducting the nominal value of a misplaced drawing from the pay of the person responsible for its loss. This practice is in keeping with the policy of charging shop personnel with the nominal value of lost tools.

PRINT-DISTRIBUTION SYSTEM

Prints of the drawings produced in the engineering department are furnished the purchasing, manufacturing, quality-control, and shipping

departments as authority for procurement of material, fabrication, assembly, inspection, and packing of the parts described on them. The method used to distribute these prints must insure that the proper quantity for each new and changed drawing reaches all departments affected.

A prerequisite to establishing a print-distribution system is the determination of points within the factory to be supplied with complete print files, also the quantity to be furnished such destinations. An ideal arrangement is one involving three basic print files in the (1) engineering, (2) production, and (3) inspection departments. In this case the production files are used to supply prints for purchasing, shop orders, tool design, subcontracting, and other points outside the engineering and inspection departments.

Although an ideal condition can rarely be attained, a definite effort should be made to maintain print-delivery points at the minimum. Identical print quantities should be furnished each delivery point for all drawings relating to a given model or article. The only exception to this rule applies to subcontracted parts where the print quantities are sometimes greater than for parts made within the factory. The drawings of these parts can be identified by placing a large asterisk immediately following the drawing number. The regular-release print quantity is shown in the margin or, preferably, within a space provided in the drawing title block. The release group can then order the additional print quantities required on each drawing release.

When print-delivery points and basic quantities are determined for each model, this data should be issued in the form of a bulletin to the release group, blueprint unit, and all print-delivery points. This bulletin serves as authority to prepare and deliver the specified prints to each delivery point. When a change becomes necessary, the bulletin is replaced with a corrected issue.

PRINT ISSUE NUMBERS

In order to maintain accurate records of print distribution and loans, each print must have individual identity. This can be accomplished by assigning an "issue number" to each print, marked in the title-block area with red crayon prior to delivery of the print. Issue number provides both (1) a serial number for the print and (2) identification of the delivery point. A two-digit number is used. The first numeral indicates the serial number of the print. The second numeral indicates the delivery point. Thus, should the engineering files receive three prints of each drawing, these can be identified as issues 01, 11, and 21. In this case "1" indicates the engineering files, while "0," "1," and "2" indicate

the first, second, and third prints. Should engineering-files release be increased to four, the fourth print would bear issue number 31. A typical distribution list for a given model might appear as follows:

PRINT DISTRIBUTION FOR MODEL 10

Destination	Quantity	Issue numbers
Production planning..	6	00, 10, 20, 30, 40, and 50
Engineering file......	3	01, 11, and 21
Inspection...........	3	02, 12, and 22
Parts-list group......	1	03
Vault...............	1	04

Such a print issue number system provides for 10 destinations and a maximum of 10 prints to each destination. When more than 10 destinations are required, a four-digit issue number can be used, with the first two numbers indicating the print serial number and the second pair designating the delivery point. For example, "0000" indicates the first print supplied the first listed destination. Likewise, "0306" indicates the fourth print furnished the seventh delivery point, whereas "1411" identifies the fifteenth print supplied the twelfth delivery point. A four-digit issue number provides identification for a hundred prints to each of a hundred delivery points and obviously accommodates sufficient prints for the needs of any organization.

SPECIAL-ISSUE PRINTS

Special-issue prints are assigned issue numbers beginning with "1" for each drawing number and prefixed *S*. Thus, the first special-issue print of a given drawing is issue number *S*1; the second *S*2; etc.

USE OF ISSUE NUMBERS

Once a basic issue number is assigned to a specific destination, it should never be used to identify another destination. If a delivery point requires prints of one model and not of another model, then the basic issue number for that delivery point must not be used in the release of prints relating to the second model. The only conditions under which an issue number should be reassigned is in the case of the complete elimination of a particular delivery point and the recall of *all* prints furnished that point.

Transparent reproductions of a drawing should use a *T* prefix to the issue number, and the number is shown in the lower margin in order to avoid defacing the printing area of the transparent.

Prints reissued on a drawing change should bear the original issue number suffixed with the change letter and then be forwarded to the identical destinations of the original issue: thus, 02*A*, 15*C*, 28*E*, and the like for regular release prints. Special-issue prints are suffixed with the change letter appearing on the drawing at the time when the print is made, and no attempt is ordinarily made to keep these up to date by forwarding prints of succeeding drawing changes.

PRINT-DISTRIBUTION RECORDS

It is necessary to maintain a record of the distribution of every print, including both regular issue and special issue. The regular-issue prints are forwarded to the established distribution points as the final step in the release of each new or changed engineering drawing. A card similar to that shown in Fig. 10:6 should be maintained by the release group for each drawing as a record of the regular-issue print distribution.

The record shown in Fig. 10:6 lists the following information for each release of the drawing, beginning with the column marked "New":

Date. Date when prints are released.
By. Initials of clerk posting record.
Job No. Number of job ticket releasing the drawing (see Chap. 9).
Models. Models for which drawing is released.

Indicated below the heavy line in each column are the standard destinations together with the basic issue number for each. The quantity of prints supplied each destination is entered in the appropriate column. When both prints and transparent reproductions are supplied, the print quantity is entered first, followed by the quantity of transparents. For example, should a destination receive three prints and one transparent, the entry would appear as "3—1."

Special-issue prints should be recorded on a form similar to that shown in Fig. 10:7, which lists the following information for each print:

Issue No. Issue number of print.
Kind. Nature of reproduction. Use *B/P* for prints and *T* for transparents.
Issued to. Name of person receiving print and address or department if outside Engineering.
Date. Date when print was issued.
By. Initials of person posting record.

The special-issue cards will be kept in engineering files (or other group delegated to handle reproduction orders) and posted by the clerk responsible for delivering prints to their destinations.

PRINT AND TRANSPARENT ISSUE RECORD DWG. NO.__________

LETTER	NEW	A	B	C	D	E	F	G	H	J	K	L
DATE												
BY												
JOB NO.												
MODELS												
COORDIN. (01)												
PRO. PLAN (02)												
EXP. PLAN (03)												
ENG. FILE (04)												
INSPECT. (05)												
ARMY (06)												
NAVY (07)												
C. A. A. (08)												
FINAL ASEM. (09)												
PARTS LIST (501)												
VAULT (502)												
______ (503)												
______ (504)												
______ (505)												
______ (506)												
______ (507)												
______ (508)												
______ (509)												

LETTER	M	N	P	S	T	U	V	W	X	Y	Z	
DATE												
BY												
JOB NO.												
MODELS												
COORDIN. (01)												
PRO. PLAN (02)												
EXP. PLAN (03)												
ENG. FILE (04)												
INSPECT. (05)												
ARMY (06)												
NAVY (07)												
C. A. A. (08)												
FINAL ASEM. (09)												
PARTS LIST (501)												
VAULT (502)												
______ (503)												
______ (504)												
______ (505)												
______ (506)												
______ (507)												
______ (508)												
______ (509)												

FIG. 10:6.—Record of regular-issue prints of new and changed drawings.

FORM 201 WB

INTERSTATE AIRCRAFT & ENGINEERING CORP

SPECIAL PRINT ISSUE RECORD DWG. NO.__________

ALWAYS STAMP "FOR REFERENCE ONLY"

ISSUE NO.	KIND	ISSUED TO	DATE	BY

KEEPING PRINT FILES UP-TO-DATE

It is necessary for each department furnished regular-release issues of prints to keep them up to date by affixing to the proper prints one copy of each drawing attachment (see Chap. 11, "Advance Engineering Information") upon receipt of same. It is also the responsibility of each department to destroy promptly obsolete issues of prints upon receipt of superseding prints bearing the same basic issue number.

ADC, EO, STOP ORDER & STOP RELEASE RECORD 10-66032								
SERIAL NO.	DATE REC.	CHG. LET	SERIAL NO.	DATE REC.	CHG. LET	SERIAL NO.	DATE REC.	CHG. LET
~~ADC 1063~~	~~2/17/43~~	~~—~~						
~~ADC 1163~~	~~2/19/43~~	~~—~~						
~~EO 586~~	~~2/19/43~~	~~—~~						
~~ADC 1261~~	~~3/2/43~~	~~A~~						
~~ADC 1293~~	~~3/5/43~~	~~A~~						
~~SO 163~~	~~3/7/43~~	~~A~~						
~~SR 163~~	~~3/14/43~~	~~A~~						
ADC 1371	4/3/43	B						

FIG. 10:8.—Record of drawing attachments.

Each print file should maintain a record card for each drawing, listing the drawing attachments issued against that drawing. Drawing attachments normally include advance drawing changes, engineering orders, stop orders, stop releases, or equivalent documents. Each attachment bears a serial number that is entered on the record card together with the date received. All outstanding drawing attachments are usually incorporated or canceled by each drawing change. Upon receipt of the changed print, it is necessary to strike out the serial number of each attachment made inactive and indicate the change letter, as shown at Fig. 10:8. Thus, the active attachments shown on each record card are those which should be attached to its respective print to provide the complete status of the drawing. Unless such a record is maintained, it is impossible to be certain that the file prints are complete with all active drawing attachments. *Each time that a loaned print is returned to the files, it should be checked to make certain that all active drawing attachments are affixed.* Often it will be found that one or more attachments have been removed while the print was on loan.

Keeping print files up to date is a problem that must be coordinated with the other departments involved. The responsibility of providing a workable procedure to maintain the prints in each department must be fully accepted by that department. The engineering department should never accept the burden of maintaining print files in other departments. Each department within an organization should handle its own internal problems and not rely upon another department to do a portion of its work.

Obsolete prints are normally removed from each file when superseding prints are received and are destroyed by either burning or shredding. The method of destruction should be approved by the plant-protection department in an organization doing work of a confidential or secret nature. The important factor is controlling the circulation of obsolete prints and avoiding use of erroneous information in the factory. It may be necessary to maintain obsolete prints in the factory files for a limited time in order to permit completion of manufacturing work in process. This is a matter concerning only the department involved and does not affect the engineering department.

It is the responsibility of persons furnished special-issue prints to return them to engineering files when informed that they are obsolete or no longer needed. It is unfeasible to keep special-issue prints up to date by forwarding drawing attachments or superseding prints. These prints should be issued on the basis of being used for reference only.

PRINT CHARGE-OUT SYSTEM

Suitable records must be maintained of all prints loaned by engineering files. The most practicable method is the use of a "charge-out" card for each loaned print. The card is filled out by the borrower and given to the file clerk who places it in the position normally occupied by the loaned print. The specimen charge-out card, shown in Fig. 10:9, is used until all lines are filled in, listing the following information for each loan:

Dwg. No. Drawing number of print borrowed.
Issue No. File clerk enters issue number appearing on print.
Name. Signature of borrower.
Date. Date of loan.

When the print is returned to engineering files, the card is removed and replaced by the print. The card is then placed on the counter ready for use by another borrower.

When superseding prints are received, the engineering files should communicate with the persons having the *superseded* prints. These

superseded prints are replaced with the new prints. The charge-out cards are changed accordingly to show the new issue numbers. When it is necessary for a borrower to retain a superseded print for reference in connection with work in process, the print should be stamped "obsolete" by engineering files.

DWG NO	ISSUE NO	NAME	DATE	DWG NO	ISSUE NO	NAME	DATE

FORM 241 EW RECORD OF LOANED BLUEPRINT (JULY - AUG - SEPT.) INTERSTATE AIRCRAFT EL SEGUNDO DIV

FIG. 10:9.—Charge-out card for record of loaned prints.

The need for retrieving all superseded file prints makes it desirable to limit print loans to engineering-department employees. When this is not done, the engineering-file prints become scattered throughout the factory, and keeping them up to date becomes a burden. Circumstances may occur, however, that justify loaning engineering-file prints to employees of other departments, and such loans should require the chief draftsman's approval.

The person borrowing a print from engineering files is responsible for its security until returned, and the borrower should not loan a print to another employee without having the files department correct the print charge-out record. In order to minimize careless handling of loaned prints, a penalty can be imposed by charging the responsible employee with the nominal cost of replacing a lost print.

PRINT INVENTORIES

At periodic intervals, all prints should be recalled to the engineering files for an inventory. Recalling prints for inventory may cause considerable loss of time in a large engineering department, because of the removal of many prints actually required for work in process. When this condition exists, a "rotating-inventory" system is preferable.

When the rotating-inventory system is used, the print charge-out cards are in four groups of white and three colors, with each group identifying a specified quarter of the year. The specimen card, shown in Fig. 10:9, is identified with the third quarter by the notation "July—Aug.—Sept." along its lower margin. Other cards are identified with the remaining quarters of the year.

The appropriate group of cards is used during each quarter. Two weeks after the beginning of a new quarter, the cards remaining in the files from the preceding quarter are withdrawn, and the charge-out prints recalled. Identification of charge-out cards relating to the preceding quarter is simple, with the use of different colors for each quarter. When this system is used, it is impossible for a print to be on loan longer than approximately three months, and a periodic inventory is obtained without disrupting the work of the engineering department.

ORDERING REGULAR-ISSUE PRINTS

Efficient operation of the blueprint unit is contingent upon the establishment of an efficient procedure for ordering prints. The procedure must involve a written order for each print or group of prints in order to provide authorization for each reproduction. This method of ordering prints will function equally well regardless of whether the printing is accomplished by a blueprint unit within Engineering or by a commercial blueprint firm.

Regular-issue prints can be ordered by indicating the required quantity of prints in the margin of the job ticket (refer to Chap. 9) opposite each drawing number. If the quantity is identical for all drawing numbers on the job ticket, this can be noted at the top of the form. The job ticket then becomes the blueprint unit's authority to make the required reproductions for each drawing release. These prints and the drawings of them are forwarded to the release group to identify each with an issue number and make the proper distribution.

ORDERING SPECIAL-ISSUE PRINTS

A reproduction order form, similar to that shown in Fig. 10:10, should be used for ordering special-issue prints. The form provides for ordering prints of 1 to 14 drawings and for different types of reproductions.

REC'D BY ______ . ______ INTERSTATE AIRCRAFT AND ENGINEERING CORP. EL SEGUNDO DIVISION DATE OF REQUEST ______

DATE ______ **REPRODUCTION ORDER** DATE REQUIRED ______

DWG NO		B & W	OZALID TRANS.	RED LINE	BLUE LINE	ROLL	FOLD	PUNCH BIND	DISPOSITION OF VELLUM	STAMP

REQUEST BY ______ SUPERVISOR'S APPROVAL ______ ENGINEERING APPROVAL ______ DATE ______

DEPT ______ FORM 200-E

FIG. 10:10.—Order blank used to requisition all types of reproductions.

The form is prepared in duplicate, listing the following information as required:

Date of Request. Date when order was written.

Date Required. Date when prints are required.

Dwg. No. Number of drawing or report to be printed. If the document requiring reproduction has no number, a brief description is entered.

Blueprint, B&W, Ozalid Trans., or Blueline. Quantity required of each drawing and report listed is entered in the column for the kind of reproduction desired. A blank column is provided for indicating other reproductions such as vandyke, photoprint, or ditto.

Roll, Fold. Appropriate space is checked to indicate whether prints should be rolled or folded.

Punch, Bind. Checked when punching or binding is necessary. "Bind" is struck out when punching only is required.

Disposition of Vellum. Where reproducible copy shall be returned when it belongs to person ordering prints.

Stamp. When prints require special stamping instead of the customary "For reference only," this is indicated.

Requested by. Person requesting prints.

Department or Group. Requester's department or engineering group.

Supervisor's Approval. Signature of person authorized to approve reproduction orders when requester is not authorized.

Engineering Approval. Signature of chief draftsman required on "rush" orders and those originating with other departments.

Date. Date of engineering approval.

The completed, approved reproduction order is presented to Engineering Files. Engineering Files forwards order and drawing or other reproducible copy to blueprint unit. Blueprint unit makes the required reproductions and returns original copy of order, reproductions and drawing to the files. Engineering Files assigns and records issue numbers to the prints and delivers them to the requester. The drawing is returned to the destination indicated on the order, except that engineering-file drawings are retained by the files after printing.

A special-issue print should be authorized only upon valid evidence that file prints cannot be used or when the print is to be forwarded to another department or company. The personnel authorized to approve reproduction orders should be limited to supervisors in order to prevent issuance of unnecessary prints.

Reproduction orders are ordinarily handled by the blueprint unit in the order of receipt, but circumstances may justify placing an order on a rush status to take precedence over other work in the blueprint unit. This practice must be carefully controlled in order to avoid the issuance of so many rush orders that "rush" becomes synonymous with "routine." All rush orders are approved by the chief draftsman.

Special-issue prints requested by other departments cannot be permitted to interfere with the production of regular-release prints necessary for factory operations. These orders require the approval of the chief draftsman. It will then be apparent to the chief draftsman when the burden of work from other departments becomes excessive, and measures can be taken to enlarge the blueprint facilities or divert the work from other departments to a commercial blueprint firm.

All reproduction orders must be handled by Engineering Files except regular-release orders, which are handled by the release group. If everyone desiring prints is permitted to take an order to the blueprint unit personally, confusion will result—for each person is always positive that his prints are more important than those of anyone else.

RECORD OF PRINT DELIVERIES

Prints delivered within the company do not ordinarily require acknowledgement of delivery. A copy of the job ticket for regular-issue prints or the original copy of the reproduction order for special-issue prints serves as a delivery notice. When prints are forwarded to desti-

nations outside the company, it is desirable to accompany them with a shipping notice prepared in duplicate. The original copy is retained by

FORM 208 W

INTERSTATE AIRCRAFT & ENGINEERING CORP
WILSHIRE DIVISION
3443 WILSHIRE BOULEVARD
LOS ANGELES, CALIF.

DATE__________ JOB NO.__________

SHIPPING NOTICE

NOTE: *Sign One Copy and Return to Engr.-Release Group*

FROM: ENGINEERING RELEASE GROUP

TO:

ATTACHED TO THIS NOTICE ARE THE FOLLOWING PRINTS:

NUMBER	ISSUE	NUMBER	ISSUE	NUMBER	ISSUE	NUMBER	ISSUE

REMARKS.__________

RECEIVED BY:__________ DEPT.:__________ DATE__________

FIG. 10:11.—Shipping notice for record of print deliveries.

the addressee; the duplicate is signed and returned as acknowledgment of receipt. A specimen shipping notice, shown in Fig. 10:11, lists the following information:

Number. Drawing numbers of prints forwarded.
Issue. Issue number of each print forwarded.

Date. Date of shipment.
Job No. Job ticket number authorizing print release.
Remarks. Notation of data peculiar to shipment.
Received by. Signature of person receiving prints on duplicate copy, then returned to Engineering.
Department. Name of department or company receiving prints.
Date. Date when prints are received.

Should interdepartmental complaints result from alleged failure to receive proper print shipments, it may be necessary to use the shipping notice for regular-issue print deliveries within the company. This practice should be avoided whenever possible since it introduces additional expense that can be eliminated by improved departmental cooperation.

In the event of persistent complaints regarding improper deliveries of special-issue prints, the spaces marked "Rec'd by" and "Date" in the upper left corner of the reproduction order can be used as an acknowledgment of delivery. The original copy of the order, returned to Files with the prints, is signed by the requester upon delivery of the prints and retained by Files as a delivery record. This practice can be eliminated in a properly organized engineering department but may be necessary when considerable inexperienced personnel is employed.

CONTROL OF OTHER-COMPANY PRINTS

Reference prints received from other companies are kept in the engineering files and loaned in the usual manner, except for a ruling that all loans must be returned before the close of each workday. This policy provides control over the location of other-company prints and effectively prevents their loss. The loss of an other-company print is more serious than loss of an engineering-department print because important work may be considerably delayed while a duplicate is obtained.

An inventory record, similar to that maintained for engineering-department drawings, can be used for other-company prints. It is more useful, however, to have a cross-reference inventory with *three* cards for each print: one by print *number*, another by print *name*, and a third by *company* name. Draftsmen will come to the files with a vague description of the other-company print desired. One may remember only the name of the print; another the name of the company; whereas a third may know the number of the print desired. The prints should be filed in numerical order, with the inventory record indicating the change letter or number appearing on each.

It may be necessary to maintain files of duplicate tracings of other-company drawings. This is the case when special parts manufactured by other companies are incorporated in a product designed by the en-

gineering department. It is then essential to furnish prints of other-company drawings to the receiving, inspection, and assembly departments, in addition to copies in engineering files. These other-company drawings are handled similarly to the drawings produced by the engineering department, being forwarded to the release group for release and then to the files for storage. The records maintained are identical with those for drawings produced in the engineering department. An arrangement must be made with the company holding the original drawings to forward a duplicate tracing of each change. These changes are released in the same manner as changed versions of drawings made in the engineering department.

CONFIDENTIAL DRAWINGS AND PRINTS

Installation and assembly drawings revealing the function of an article classified as "confidential" should be handled as confidential

ISSUE NUMBER	PRINTED BY	DATE	AUTHORIZED BY	RECEIVED BY
S-1	M. Wolfer	15 Feb. 44	Vault	Copy
S-2	M. Wolfer	16 Feb. 44	J. E. Thompson	A. L. Henry
S-3	M. Wolfer	16 Feb. 44	J. E. Thompson	A. L. Henry

FIG. 10:12.—Printing record block for confidential drawings.

drawings. Subassemblies and details of these drawings ordinarily need not be considered as confidential. A definite effort should be made to maintain the quantity of confidential drawings at the minimum because each requires special handling with additional expense.

A procedure must be inaugurated to govern the establishment of confidential status for drawings. An acceptable method for government contracts involves the mutual agreement of the chief engineer and government representative as to what drawings are considered confidential. A list of these confidential drawings is furnished the release group, Engineering Files, blueprint unit, and all recipients of regular-release prints.

Confidential drawings are identified by placing the word "confidential" (printed in boldface letters, 1 in. high) on a 6-in. wide protector strip forming an extension of the tracing's right-side margin. A printing record similar to that shown in Fig. 10:12 also appears on the protector strip.

All persons involved in the authorization, reproduction, and receipt of each confidential print must affix their signatures in the printing-record block on the drawing. A special-issue print record similar to that shown in Fig. 10:7 is maintained in the engineering files. Each print of a confidential drawing requires the signature of the chief engineer or of a person delegated by the chief engineer. Prints of confidential drawings are obtained by writing a reproduction order in the usual manner. It is the chief file clerk's duty to obtain the drawing, secure the necessary signatures and prints, and deliver them—then return the drawing to Files.

Only a "vault copy" of each confidential drawing should be in the files since there must not be a regular release of these drawings. All prints required for the factory are individually authorized. A minimum of factory prints should be issued, and the foremen receiving them are responsible for their safekeeping and return.

ENGINEERING REPORTS

The term "engineering report" includes all specifications, stress analysis, sales reports, service bulletins, handbooks, manuals, and other documents prepared by the engineering department for distribution outside engineering. Many of these documents are equally important as drawings and should receive the same care.

The original, reproducible copy of each report is filed in the same manner as a drawing, and at least one file copy of each should be available for loan. The filing, records, and loans should be accomplished similar to drawings and prints.

The numbering, release, and distribution of reports are normal functions of the engineering librarian and are detailed in Chap. 14. A small engineering department, in which the existence of a separate library function cannot be economically justified, should have this work accomplished by Engineering Files, but the methods described in Chap. 14 still apply.

BLUEPRINT UNIT

The blueprint unit is usually a part of engineering but may sometimes be a commercial blueprint company. When the work is accomplished within Engineering, the blueprint unit should be operated as though it were a small business enterprise, divorced from actual contact with the general engineering personnel. All ordering and delivery of work are accomplished through the release and engineering-file groups. In this manner an efficient blueprint unit can be operated and minimum cost maintained.

Several methods are used to produce drawing reproductions, but these can be grouped into two basic forms: (1) blueprints and (2) direct-line prints. The former class includes blue-line prints, which are simply prints produced on blueprint paper by using a vandyke negative of the original drawing. The latter class includes the Ozalid, Bruning, and related methods of producing a black- or brown-line print directly from the drawing.

The relative merits of these processes are governed by the quantity of reproductions involved. The blueprinting process is most economical and rapid when large print quantities are required. This provides a continuous backlog of work in order to insure operation of the printing machine a greater part of the working day. On the other hand, the blueprinting process requires a complicated installation. This involves a continuous supply of fresh water, sewage connections for waste water, and considerable space for the machine itself.

A direct-line printer is usually more practicable than a blueprint installation for a small engineering office. The space requirements are less, and the initial cost is low. The installation can be readily moved in the event of departmental rearrangements and requires less training for the operator. All direct-line printers are either (1) dry developing or (2) wet developing, and choice of the process is governed entirely by the preference of the purchaser, as both give satisfactory results. It is well to keep in mind, however, that since dry-developing machines usually employ ammonia gas as the developing agent, a fume hood with adequate forced-draft ventilation must be provided. Wet-developing machines, on the other hand, require frequent mixing of fresh developer and cleaning of the developing apparatus but do not ordinarily need a fume hood.

A large engineering department should have both a blueprint machine and a direct-line printer in the blueprint unit, similar to the arrangement shown in Fig. 10:13. Here, the blueprint machine is seen in the foreground, and in the background there is a wet-developer direct-line printer. When both types of printing machines are available, the blueprint machine can be used for all production runs, such as drawing releases, and the direct-line printer for miscellaneous printing of reports, specifications, reference prints of drawings, standards-book pages, and the like. The direct-line machine is particularly adapted to the printing of report and specification pages. Sheets of sensitized paper cut to 8½ by 11 in. can be obtained to eliminate the annoyance of hand-trimming.

In the choice between the blueprint or direct-line process, an important factor is the feasibility of continuously feeding sensitized paper through a blueprint machine. The prints are trimmed to size as the

paper discharges from the back of the developing unit onto the cutting table. Direct-line machines, on the other hand, do not ordinarily have a precise feeding mechanism, and it is difficult to print a drawing longer than 12 ft. without having the paper wrinkle. The operator must cut the sensitized paper and reinsert it between the feed belts for each drawing printed.

Irrespective of the nature and quantity of equipment in the blueprint department, it should be operated on the basis of a separate "business." All orders and deliveries are then handled through the engineering

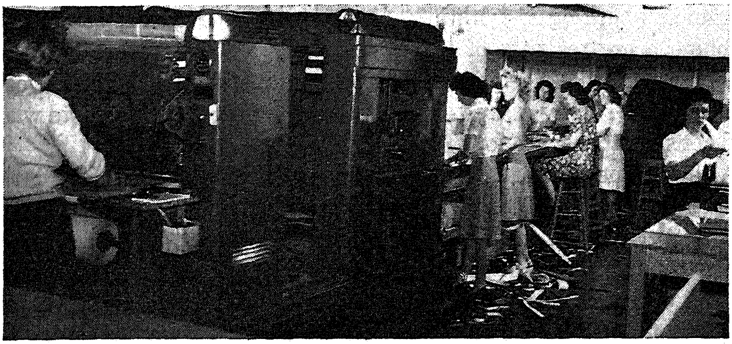


Fig. 10:13.—Blueprint unit in typical engineering department. (*Courtesy Ryan Aeronautical Co.*)

release and files groups. This list of "customers" can be expanded to include the engineering library in the case of reports. Furthermore, it is vitally necessary to provide ample space, adequate lighting, and proper ventilation if efficient operation is to be achieved.

USE OF DUPLICATE TRACINGS FOR PRINTING

An engineering department serving a large factory must frequently supply several dozen prints of each drawing release. Obviously, repeated printing will rapidly deteriorate the drawings, and an arrangement must be found to reduce the wear on the drawings. This problem can be solved by using the original drawing only to prepare a duplicate tracing upon each release. The original drawing is then returned to Files until required for a drawing change. The duplicate tracing (which may be vandyke, direct-line transparent, or phototracing) is used for all printing and is discarded when the drawing is rereleased under the next change letter. The cost of preparing a duplicate tracing is negligible when compared with the cost of retracing the original drawing.

TYPESCRIPT-DUPLICATION PROCESSES

Every engineering department has a need for the rapid, inexpensive duplication of typescript material, and either the hectograph or mimeograph process is satisfactory for this purpose. The equipment should be located in the blueprint unit in order to provide centralized control of all duplicating processes in the engineering department. It is sometimes believed that the typescript-duplicating equipment for the entire factory should be centralized in one location. Although there is much in

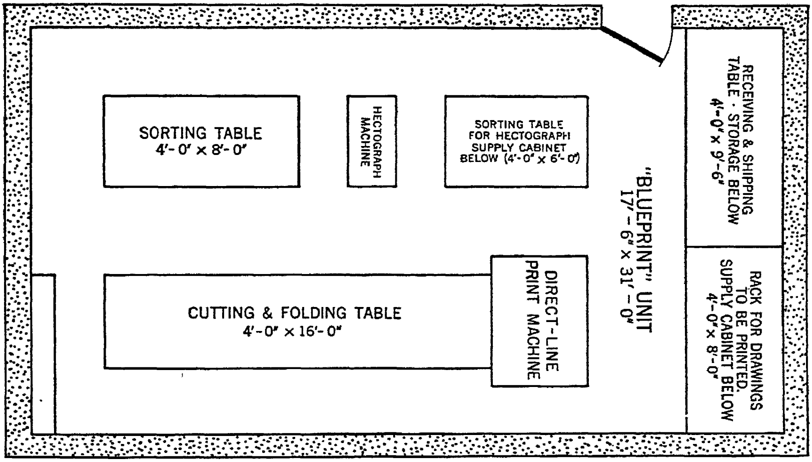


FIG. 10:14.—Floor plan for "blueprint" unit.

favor of this arrangement, an exception must be made in the case of Engineering. This is due to the fact that Engineering frequently issues emergency instructions to the factory that require immediate duplication and distribution (see Chap. 11). Routing these instructions through a central duplicating department frequently causes their distribution to be delayed. This cannot be tolerated, and the best solution is separate duplicating facilities for Engineering.

CONTROL OF ORIGINAL AND DUPLICATE METAL DRAWINGS

Some engineering departments prepare drawings upon metal sheets in order to permit the reproduction of metal copies of the original drawings to exact scale. These copies are used to make templates (or even actual parts for an experimental model) by trimming around the outside edges of the developed pattern shown on the drawing. When metal drawings are used in conjunction with drawings prepared upon transparent me-

diums, additional filing, reproduction, and distribution problems are introduced. Such difficulties can be overcome by applying the basic methods outlined here for cloth and paper drawings.

Metal drawings are filed by drawing number in the same manner as other drawings, but special filing provisions are necessary. Racks with vertical slots to support the metal sheets in an upright position are used. An inventory system identical to that maintained for the other drawings can be employed. All reproductions can be ordered and released in the manner previously described for transparent drawings. Distribution of metal-drawing reproductions can be handled similarly to prints of tracings.

In keeping with a policy of centralized control over all engineering reproduction processes, the reproduction of metal drawings should be a function of the blueprint unit. There are several methods of reproducing metal drawings, including (1) photographic, using glass negatives; (2) contact printing, with fluorescent coatings on the metal; (3) contact printing by X ray; and (4) lithographic prints. Each method requires extensive equipment, including cameras, large developing and fixing tanks, printing frames, and silk-screen coating equipment. In each case adequate, well-planned working space is required for efficient operation.

SUMMARY

The information contained in this chapter can be briefly summarized as follows:

a. The establishment of practical, efficient procedures (1) to control the handling and filing of drawings and (2) to order, issue, and recall prints is a prerequisite to efficient operation of an engineering department.

b. Drawings are stored in the engineering files and made the responsibility of a designated employee. An inventory record is maintained for the drawings.

c. Drawings are normally loaned by the files only for drawing changes or printing.

d. A written charge-out record is maintained for all drawings loaned by the files.

e. All prints prepared from company drawings are assigned issue numbers in order to establish individual identity, and a record is maintained of print distribution.

f. Prints reissued on a drawing change bear the original issue number, suffixed with the change letter, and are forwarded to the destinations of the original issue.

g. Print files are kept up to date by attaching one copy of each drawing attachment immediately upon receipt and by promptly replacing superseded prints.

h. A written charge-out record is maintained for all prints loaned by the files.

i. An inventory of the drawings and prints in the file is taken at regular intervals.

j. The system of ordering reference prints of drawings and documents permits the blueprint unit to function as a separate enterprise. Orders are received from a few designated sources rather than from the entire engineering department.

k. A procedure to insure the security of confidential drawings and prints is necessary.

l. Reference prints and drawings received from other companies are filed, released, and loaned in an orderly manner, similar to that used for engineering-department drawings.

m. A system is established to govern the filing and handling of engineering documents, including reports and specifications.

n. Duplicate tracings are used for printing purposes whenever large print quantities are required.

o. Facilities for duplication of typewritten material should be provided for the engineering department and handled by the blueprint unit.

p. When metal drawings are used, it is necessary to provide facilities for their filing, reproduction, and distribution; the basic methods used for cloth and paper drawings can be applied.

CHAPTER 11

ADVANCE ENGINEERING INFORMATION

Every engineering department requires simple, practical means for rapidly issuing instructions to the manufacturing departments. The time needed to issue a new drawing or a drawing change usually renders these mediums unsatisfactory, and new methods must be developed. They must adequately provide for issuance of *stop orders* to halt manufacture of a specified part immediately, *advance drawing changes* to provide immediate drawing-change information, and special *engineering orders* authorizing tests, drawing deviations, and parts salvage.

A small engineering department will have correspondingly little need for the advance drawing change since the time required to check and approve a drawing change prior to release (see Chap. 9) is often sufficiently short to permit issuing new prints on all changes. This is not the case in a large department, where a week or more may be required to process the drawing through the release system. In all cases there is a genuine need for stop orders and engineering orders. A positive method of halting manufacture is vitally necessary, and there must always be a definite record of drawing deviations and salvaged parts.

Three documents are used for transmittal of advance engineering information: a stop order, advance drawing change, and engineering order, as shown in Figs. 11:1, 11:5, and 11:6. Separate, distinctly different forms are used for each. All possibility of confusion is thereby eliminated, and the maintenance of records relating to their issuance is greatly simplified. Each is an 8½- by 11-in. form, preferably a hectograph master to permit rapid duplication of copies or upon tracing paper for blueprint duplication as an alternative.

STOP ORDER

A stop order is issued when manufacturing operations must be immediately halted on parts previously released for manufacture and when impending changes will require rework, scrapping, or disassembly of the parts. Considerable judgment must be used in the issuance of stop orders, for it may be less expensive to permit completion of some parts,

even when it appears that they will be scrapped, than to halt work on a large assembly while determining if a few minor parts can be salvaged.

Stop orders originate in the engineering department upon receipt of information that indicates the advisability of halting manufacture of the part or parts involved. Prior to actual issuance of the stop, a "work-status report" is obtained from Manufacturing Planning. The information contained in this report permits the engineering supervisor affected by the impending change to decide upon the wisdom of issuing a stop order. The work-status report is obtained by preparing a stop-order original (on hectograph master paper or vellum, as the case may be) indicating the production serial number of the unit upon which the stop will be effective, the model, part name, part number, dash-number parts affected (only those listed are stopped), and the reason for the stop. The effect of the stop upon raw-stock materials required for manufacturing the part is also shown. The specimen stop-order form in Fig. 11:1 is used both to issue and to release a stop against a specified drawing, listing the following information in each case:

When Stop Order Is Issued:

Stop-order No. Assigned by engineering release group when stop-order original is received.

Effective on. Production serial number of unit (or numbers if more than one model is affected) that stop is effective upon. Work will be completed on all units perceding this serial number.

Model. List only models that stop is effective on.

Part Name. Same as drawing name or title.

To Be Filled in by Planning. Manufacturing-planning department record of action taken to halt manufacture.

Reason for Stop. A clear, concise explanation of the necessity for issuing the stop.

Part No. Same as drawing number.

Serial No. Cost-control record (see Chap. 4).

Dash Nos. Dash-number parts to be stopped (see Chap. 6).

Stop Material. Refers to raw-stock material. Check either "Yes" or "No."

Parts Status. Filled in by manufacturing-planning department when stop-order original is forwarded for work-status report.

Raw-stock Status. Filled in by material-control section of Manufacturing Planning when stop-order original is forwarded for work-status report.

Tooling Status. Filled in by tooling section of Manufacturing Planning when stop-order original is forwarded for work-status report.

Engineering Approval. Originator of stop signs as "draftsman." Originator's supervisor signs as "group leader," authorizing forwarding to Manufacturing Planning for work-status report. Project engineer signs after work-status report is received and decision made to issue stop. Chief engineer (or delegated engineering executive) authorizes issuance of stop.

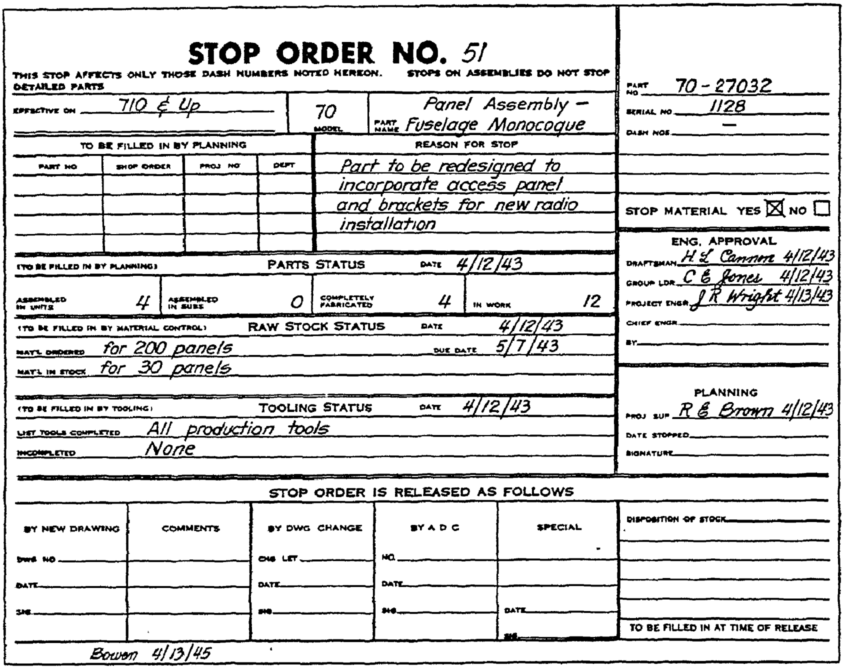
Planning. Project supervisor in Manufacturing Planning signs before returning original with work-status information. "Date stopped" and "signature" for manufacturing-planning record of action taken to halt manufacture.

When Stop Order Is Released:

Stop Order No. The word "order" is changed to "release."

Stop Order Is Released as Follows. The method of release is entered in the appropriate space. The "special" block is used when the stop is canceled by entering "Use without change." The signature is that of the engineering supervisor inaugurating the stop.

Disposition of Stock. "Stock" refers to the finished and semifinished parts manufactured prior to issuance of the stop order and impounded in the stop-order storeroom. There are five normal conditions of stock disposition: "use," "rework," "scrap," "return to stock," and "none." The latter is applicable when there is no stock. The stock disposition shown must be identical with that shown on the relevant drawing-change notice or ADC.



STOP ORDER NO. 51

THIS STOP AFFECTS ONLY THOSE DASH NUMBERS NOTED HEREON. STOPS ON ASSEMBLIES DO NOT STOP DETAILED PARTS

EFFECTIVE ON 710 & Up

MODEL 70

PART NAME Panel Assembly — Fuselage Monocoque

PART NO 70-27032

SERIAL NO 1128

DASH NOS —

TO BE FILLED IN BY PLANNING

PART NO	SHOP ORDER	PROJ NO	DEPT

REASON FOR STOP

Part to be redesigned to incorporate access panel and brackets for new radio installation

STOP MATERIAL YES ☒ NO ☐

(TO BE FILLED IN BY PLANNING) PARTS STATUS DATE 4/12/43

ASSEMBLED IN UNITS 4 | ASSEMBLED IN SUBS 0 | COMPLETELY FABRICATED 4 | IN WORK 12

(TO BE FILLED IN BY MATERIAL CONTROL) RAW STOCK STATUS DATE 4/12/43

MAT'L ORDERED for 200 panels DUE DATE 5/7/43

MAT'L IN STOCK for 30 panels

(TO BE FILLED IN BY TOOLING) TOOLING STATUS DATE 4/12/43

LIST TOOLS COMPLETED All production tools

INCOMPLETED None

ENG. APPROVAL

DRAFTSMAN H L Cannon 4/12/43

GROUP LDR. C E Jones 4/12/43

PROJECT ENGR. J R Wright 4/13/43

CHIEF ENGR.

BY

PLANNING

PROJ SUP R E Brown 4/12/43

DATE STOPPED

SIGNATURE

STOP ORDER IS RELEASED AS FOLLOWS

BY NEW DRAWING	COMMENTS	BY DWG CHANGE	BY A D C	SPECIAL
DWG NO		CHG LET	NO	
DATE		DATE	DATE	
SIG		SIG	SIG	DATE
				SIG

DISPOSITION OF STOCK

TO BE FILLED IN AT TIME OF RELEASE

Bowen 4/13/45

FIG. 11:1.—Stop order.

A separate stop order is written for each part to be stopped, although several dash-numbers parts can be halted by one stop. This policy of individual stops provides a complete and separate history for each drawing and must be followed to insure a comprehensive drawing-release record. Copies of each stop are attached to every print of the stopped drawing, and the use of separate stop orders insures halting manufacture on all of the parts affected.

Work-status Report

The stop-order original is delivered to the engineering release group for forwarding to the manufacturing-planning department. This does *not* constitute release of the stop but simply an official request to Manufacturing Planning to furnish a work-status report on the proposed stop order.

Upon receipt of the proposed stop order by Manufacturing Planning, an immediate investigation is made to obtain the required information on materials, tooling, and parts affected by the proposed stop. These data are entered in the spaces on the stop order marked "Parts Status," "Raw Stock," and "Tooling." The proposed stop order is then returned through engineering release to its originator as a work-status report.

After receiving the work-status report the engineering supervisor who originated the proposed stop can decide the advisability of its issuance. It may be found that, although a change is desirable, the quantity of completed parts makes the change unfeasible. On the other hand, large quantities of raw-stock materials may have been received, and the time delay required to obtain new materials would be prohibitive. A considerable quantity of expensive tooling may have been completed, and the change would necessitate either scrapping or reworking these—with accompanying expense and production delay.

In each case it is necessary to weigh the cost of the change against the improvement gained by the change. This assumes that the proposed change may be classified as desirable rather than mandatory because of design deficiencies or changes in customer requirements. In the latter cases there is no question about issuing the stop as soon as possible. The work-status report is then useful only in determining the best methods of salvaging as much as possible of the completed tooling and parts.

Effect of Stop Order on Other Departments

The effect of a stop order upon other departments should also be considered when deciding upon its issuance. Issuance of a stop literally throws a wrench into the production machinery by immediately halting all work upon the part involved. The manufacturing-planning department must immediately recall all shop orders issued for the part and locate all parts in process of fabrication or assembly and all completed parts in the stock rooms. Both semifinished and completed parts must be impounded in a separate stop-order storeroom in order to prevent the possibility of their use, and they must remain there until the stop is released.

This withdrawal of stopped parts from manufacturing results in dislocation of production schedules and machine loadings and requires that other work be rescheduled immediately to absorb the machine and assembly time suddenly released by issuance of the stop. Upon subse-

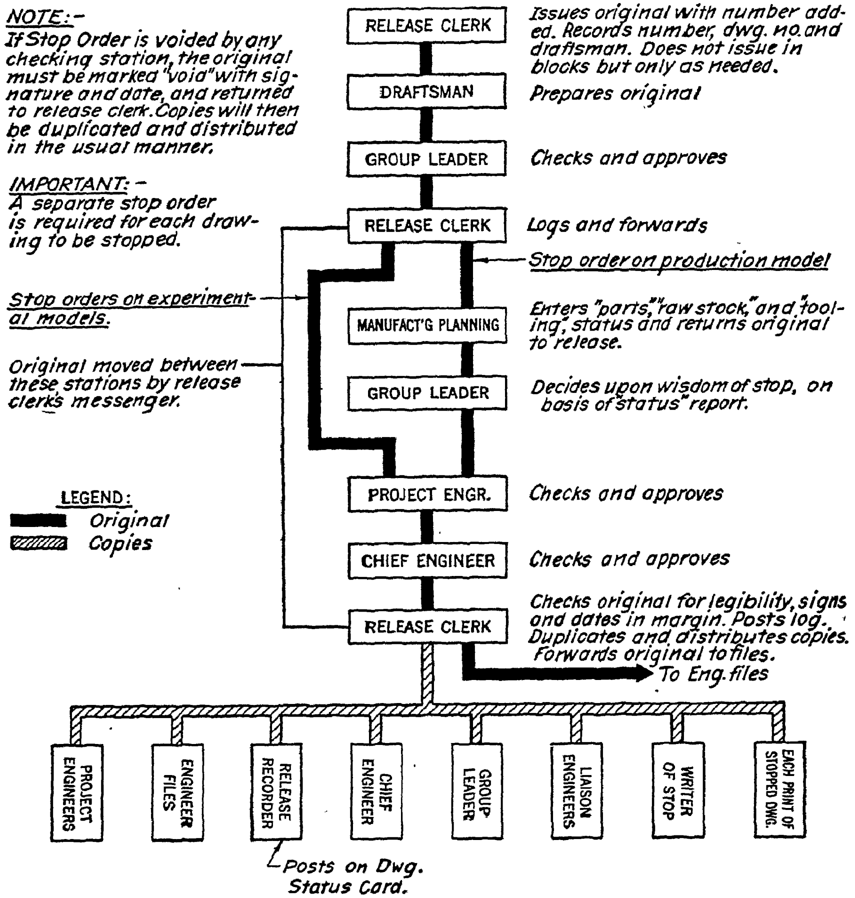


FIG. 11:2.—Procedure for issuing a stop order.

quent release of the stop this process must be reversed. Each case upsets a portion of the manufacturing planning, with resultant confusion and expense.

The tool-design and tool-manufacturing departments halt all work on the tooling for the stopped part upon receipt of advice from the manufacturing-planning department. There are corresponding schedule changes and impounding of tooling in process and stores and of tools

used by the factory. Material-control and -purchasing departments take action to halt deliveries of raw-stock materials in some cases, and the outside-production department is affected by stops on parts subcontracted to feeder shops.

If the possible cost and confusion resulting from issuance of a stop are considered, it is obvious that this innocuous-appearing document should be issued only in extreme cases. Its use should be restricted to urgent, mandatory changes, where it is known that all future expenditure on the part will be waste. In such cases there should be no hesitation regarding issuance of a stop order. Even though a drawing change could be completed and released within two days, the immediate issuance of a stop order might easily avoid the manufacture of several hundred useless parts.

Issuing a Stop Order

If, after weighing all factors involved, it is decided that issuance of a stop order is justified, the approval of the project engineer and chief engineer is obtained, and the stop-order original is forwarded to Engineering Release for duplication and distribution of the required copies. Should the decision be *not* to issue the stop, the original is marked "Void," together with the originator's signature and the date, and is forwarded to Release. Copies are distributed only to the engineering department and to manufacturing-planning files; none are attached to prints. This informs Manufacturing Planning of the disposition of each proposed stop order and avoids uncertainty regarding pending stops. This is necessary in fairness to Manufacturing Planning since each stop dislocates their production "machinery," and even the suggestion of a stop is cause for concern.

Emergency Stop Order

Circumstances may arise that make mandatory issuance of an immediate stop on a certain part. This can be done without securing a work-status report from Manufacturing Planning, upon authorization by the chief engineer.

Stop Orders on Experimental Models

Stop orders on parts for experimental models are not sent to Manufacturing Planning for a work-status report, as shown by the routing in Fig. 11:2. The quantity of parts and materials involved with an experimental model is small, and speed in issuing the stop is of paramount importance.

Stopped Drawing Cannot Be Rereleased

Issuance of a stop order not only halts all work in the factory on the part affected but also prevents further release of its drawing. In other words, the stop must be released before the drawing can be rereleased under the next drawing-change letter. Drawing changes on a stopped part are wasted effort unless for the purpose of releasing the stop.

STOP ~~ORDER~~ RELEASE NO. 51

THIS STOP AFFECTS ONLY THOSE DASH NUMBERS NOTED HEREON. STOPS ON ASSEMBLIES DO NOT STOP DETAILED PARTS

EFFECTIVE ON 710 & up | MODEL 70 | PART NAME Panel Assembly—Fuselage Monocoque

TO BE FILLED IN BY PLANNING				REASON FOR STOP
PART NO	SHOP ORDER	PROJ NO	DEPT	Part to be redesigned to
				incorporate access panel
				and brackets for new radio
				installation

(TO BE FILLED IN BY PLANNING) PARTS STATUS DATE 4/12/43

ASSEMBLED IN UNITS 4 | ASSEMBLED IN SUBS 0 | COMPLETELY FABRICATED 4 | IN WORK 12

(TO BE FILLED IN BY MATERIAL CONTROL) RAW STOCK STATUS DATE 4/12/43

MAT'L ORDERED for 200 panels DUE DATE 5/7/43

MAT'L IN STOCK for 30 panels

(TO BE FILLED IN BY TOOLING) TOOLING STATUS DATE 4/12/43

LIST TOOLS COMPLETED All production tools

INCOMPLETED None

PART NO 70-27032

SERIAL NO 1128

DASH NOS —

STOP MATERIAL YES ☒ NO ☐

ENG APPROVAL

DRAFTSMAN H L Cannon 4 12 43

GROUP LDR C E Jones 4-12-43

PROJECT ENGR J R Wright 4-13-43

CHIEF ENGR

BY

PLANNING

PROJ SUP R E Brown 4-12-43

DATE STOPPED 4/13/43

SIGNATURE R E Brown

STOP ORDER IS RELEASED AS FOLLOWS

BY NEW DRAWING	COMMENTS	BY DWG CHANGE	BY A D C	SPECIAL
DWG NO 70-27061		CHG LET	NO.	
DATE 4/25/43		DATE	DATE	
SIG C E Jones		SIG	SIG	DATE
J. R Wright				SIG

Bowen 4/13/45

DISPOSITION OF STOCK Rework

TO BE FILLED IN AT TIME OF RELEASE

Fig. 11:3.—Stop release. Accomplished in this case by issuance of a new drawing.

Release of Stop Order

After the necessary drawing changes have been made, the stop order is released by entering appropriate information at the bottom of the stop original and substituting the word "Release" for the word "Order" at the top of the form, as shown in Fig. 11:3. *The original used to issue the stop is employed to effect its release.* Thus both the stop and its release bear the same serial number to insure immediate coordination. The stop release accompanies the new and/or changed drawings effecting the release throughout the engineering checking and approval system. In no case is the stop release forwarded separately.

The stop release always indicates disposition of parts in finished stores.

All drawing notices of change and ADC's involved in releasing the stop must show identical stock disposition instructions and bear the notation "This releases stop order (number)."

Canceling a Stop Order

Sometimes it will be found that a stop has been issued in error, or subsequent investigation may reveal facts that make the stop unnecessary. In such cases the stop order is canceled. This is accomplished

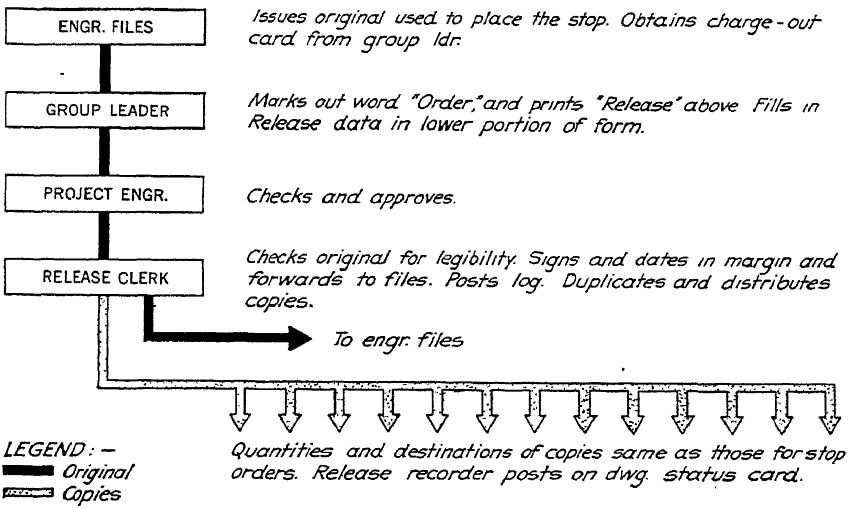


Fig. 11:4.—Procedure for releasing a stop order.

by placing the notation "Use without change" in the stop-release block entitled "Special" and forwarding the stop original to Release for distribution of copies. In this case neither drawings nor ADC's would accompany the stop release.

Records of Stop Orders and Stop Releases

A record of each stop order and stop release is maintained by Engineering Release, using the drawing-status record cards for that purpose (see Chap. 9). The stop-order number, date, and production serial number of the unit upon which the stop is effective are recorded at the time when copies of the stop are distributed. Upon release of the stop being effected, the date of its release is posted on the record. A red signal is placed upon the status card for the stopped drawing when the stop is distributed and remains until the stop is released.

Stop orders should be released as soon as possible since each represents a production delay. The stopping of one part usually results in hindering the completion of others. A stopped detail part prevents completion of its next assembly, and lack of the next assembly may prevent completion of the final assembly. A weekly summary of stop orders and stop releases is prepared and distributed to all engineering supervisors and executives by Release. This report lists all active stops and those released during the preceding week and serves as a reminder to take action on unreleased stops.

ADVANCE DRAWING CHANGE

The advance drawing change (ADC), shown in Fig. 11:5, is used by the engineering department when the need for drawing-change authorization is so urgent that it cannot be handled with sufficient rapidity through the regular release procedure. Issuance of an ADC is a guarantee that the drawing will be changed accordingly and rereleased as soon as practicable. An ADC may be issued in lieu of a drawing when time does not permit preparing and releasing a new drawing in the usual manner. In such cases a new drawing number is assigned for the new part described by the ADC.

The ADC is used *only* for information to be incorporated in a drawing. The issuance of special information not relating to drawing changes is accomplished by the engineering order shown in Fig. 11:6. In this manner it is possible readily to segregate advance engineering information relating to drawing changes from that involving items that do not affect drawings.

A copy of each ADC is attached to every print of the drawing affected. Their use permits immediate issuance of change information without the necessity of reprinting the drawing and issuing revised prints to all departments. The use of an ADC effects a considerable saving in the case of a minor change on a large drawing by eliminating printing many copies of the drawing.

After several ADC's have been issued against a drawing, it is brought up to date by incorporating all the ADC information and then rereleased under the next change letter. In this manner it is necessary to print and distribute copies of the drawing far less frequently than would be required by rereleasing the drawing for each individual changed item. In the case of major changes, however, it is usually better to change the drawing than to issue an ADC. It is generally difficult to describe a major change adequately within the space available on an ADC.

Preparation and Approval of ADC

Each ADC is prepared by or under the direction of an engineering supervisor. Sketches and explanations are used to indicate clearly the action to be taken by manufacturing departments. It is rarely necessary to use precision drafting when preparing an ADC. The prime reason for its issuance is speed in conveying information to the manufacturing departments, and in most cases freehand sketching is entirely adequate. Accurate information is the important consideration. ADC's should be issued on a form similar to that shown in Fig. 11:5, which provides for the following information:

Body of ADC. The body of the ADC is used to detail information conveyed to the manufacturing departments. A grid of light-blue lines provides an aid to sketching. The zone location of the change should be indicated.

ADC No. Assigned by engineering-release group when ADC original is received.

Written against . . . Change Print. Drawing-change letter appearing on drawing at the time when the ADC is prepared. Copies of the ADC are attached only to prints bearing this change letter.

Model. List only models on which ADC is effective.

Effective on. Production serial number of unit (or numbers if more than one model is affected) on which change is effective. All units preceding this serial number will be completed without the change described by the ADC.

Drawing Title. Title of drawing to be changed.

Next Assembly No. Number of next assembly of drawing to be changed. Indicate if "affected" or "not affected" by the change described on the ADC. If affected separate ADC's must be simultaneously issued to describe the change required on each next assembly.

Interchangeability. Indicate if interchangeability of the part (drawing) will be "affected" or "not affected" by the change. If affected other ADC's must be simultaneously issued to provide adequate service data stipulating the serial numbers of units using old and new versions of the part. See Chap. 12 for detailed instructions.

Dwg. Serial No., Dash No., Project No., and Item No. Cost-control record (see Chap. 4).

Released. Release date of ADC. Entered by release group.

Change Request No. An ADC issued in response to a drawing-change request shows here the serial number of the request.

Reason. A clear, concise explanation of the necessity for issuing the ADC.

Check Tooling Affected. Indicate if the change will affect a "mold," "forging," "die," "pattern," master jig fixture (MJF), template (Temp), or assembly jig (AJ). If tooling is not affected, place "None" in blank space.

Disposition of Stock. Stock refers to completed parts that do not incorporate the change described by the ADC and has no relation to raw-stock material. Check the desired disposition. If ADC is issued in conjunction with a stop release, the stock disposition must be identical with that shown on the release.

Signature Block. Originator of ADC signs as "draftsman." Originator's supervisor signs as "section leader," authorizing the forwarding of ADC to Release. Supervisors of release-system stations sign in "Check," "Stress," "Tooling," "Manu-

facturing-Planning," and "Project-Engineer" spaces. Customer's representative signs in "Government" space if changes require customer approval. This should be changed to "Customer" when the product is not manufactured under government contract. Release supervisor signs in "Release" space when ADC completes system.

Special Information. Occasional ADC's require special information not provided on the form shown in Fig. 11:5, and this can be added as notes above the title block. When another company is manufacturing the identical article under license, it is necessary to note "Mandatory Change for Prime Contractors" on all ADC's that must be incorporated on parts manufactured by the other company. Only changes affecting interchangeability, performance, or structural integrity are usually considered mandatory. When an ADC is issued to cancel a drawing, it is always necessary to note either "Replaced by (dwg. no.)" or "Not Replaced."

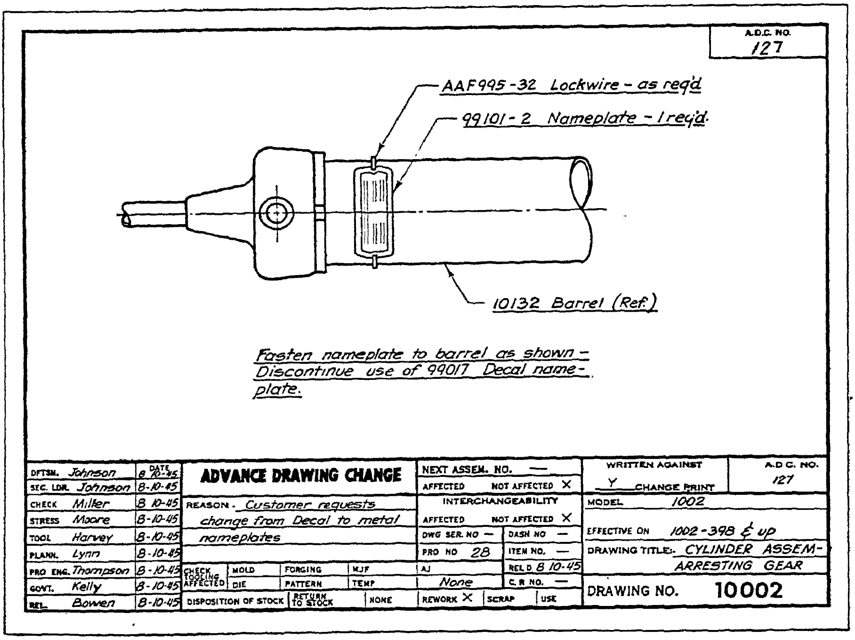


FIG. 11:5.—Advance drawing change.

Following preparation and approval by the supervisor in charge of the originating engineering group, the ADC is forwarded to Release for serial-number assignment and routing through the system. The release system should be similar to that shown in Fig. 11:7. This provides for checking and approval by a checking group, stress group, manufacturing-planning department, project engineer, and customer's representative. A small engineering department or one engaged in the design of comparatively simple products will not usually require the complete

system shown in Fig. 11:7. In such cases the system can usually be confined to checking, followed by the chief engineer's approval. Customer's approval is usually required only in the case of government contracts on complex articles manufactured in accordance with government design specifications.

The checker's investigation consists of a "spot check" to ascertain that the ADC is properly prepared, with all required data entered in a legible and understandable manner, and that it appears reasonable and proper. Accuracy of the change information in the ADC is the liability of the engineering supervisor responsible for its issuance.

Time is the essence of an ADC since the only justification for its usage is decreasing the time required to issue information to the manufacturing departments. The routing of ADC's through the checking and approval system cannot be left to chance and should be made the prime duty of an alert, aggressive member of Release. This employee personally forwards ADC's between release-system stations and maintains a record of the time at each station in the system. A total system time of 4 hr. is the maximum that can be allowed for an ADC, and it is the duty of the ADC dispatcher to effect the release within that period. When an ADC is delayed owing to circumstances beyond the authority of the dispatcher, he immediately refers the case to the chief draftsman or chief clerk, depending upon what phase of the release system is at fault.

Distribution of ADC

After the ADC completes the system, the required copies are duplicated and distributed by Release. In addition to copies for various files throughout the company, one copy is attached to each regular-issue print of the drawing affected. Whenever an ADC is attached, a small hole is punched in the margin of the print directly below the title block. This provides a ready check upon the completeness of ADC's attached to the print. There should be the same number of ADC's attached as there are holes punched in the print margin. If not, the user of the print should obtain from Release the serial numbers of all active ADC's issued against the drawing. The missing attachments can then be identified and copies obtained from Release.

Supplementary Sketch

When the ADC form does not provide sufficient space to describe the change adequately, a supplementary sketch must be made on tracing paper. The ADC is prepared in the usual manner except that it is

plainly marked "Sheet 1 or 2 Sheets." The supplementary sketch is not assigned a drawing number but instead is identified in the lower right-hand corner with the corresponding ADC serial number and is marked "Sheet 2 or 2 Sheets." All signatures appearing on the ADC also appear on the sketch. This can be facilitated by using a rubber stamp to impress a duplicate of the ADC title block on the sketch. The ADC and sketch are routed together, and when the system is completed, the sketch is forwarded by Release to the blueprint unit for preparation of the required prints. The supplementary sketch is forwarded to Engineering Files for filing with the ADC original after the necessary prints have been obtained.

Emergency ADC Issued by Liaison Engineer

In every manufacturing enterprise of any size there is usually an engineering liaison function. The personnel assigned to Liaison Engineering serve as the only direct contact between engineering and the manufacturing departments, receiving and answering all requests for engineering information and assistance. This insures that all requests from the manufacturing departments are quickly and accurately answered and provides complete coordination between Engineering and the other departments. In the absence of an engineering liaison function it will be found that an unreasonably large portion of each engineering supervisor's time is spent handling requests from the factory. Even worse, much misinformation will be supplied the manufacturing departments—as the inevitable result of decentralized responsibility.

The liaison engineers represent the most experienced, competent engineering personnel and should be authorized to issue emergency ADC's without the necessity of formal checking and approval. The issuance of emergency ADC's, however, is confined to cases arising after the normal working hours of the engineering department or when the need for engineering authorization is so urgent that it cannot be handled through the regular release procedure.

Each emergency ADC has its serial number prefixed *X* for identification. In some cases it may be necessary for the liaison engineer to obtain approval of the customer's representative prior to releasing the ADC. Only sufficient copies are distributed to take care of the immediate need, and the ADC original is then forwarded to Release for processing by the usual checking and approval system. After the ADC has completed the release system, the *X* is removed from its serial number, and copies are distributed in the usual manner.

If the emergency ADC is found undesirable or in error when checked, it is plainly marked "Canceled," together with authorizing signature

and date, then duplicated and distributed in the usual manner. Another ADC is simultaneously issued to provide the correct information and cross referenced to the canceled emergency ADC. When competent personnel are assigned to Liaison Engineering, the quantity of incorrect emergency ADC's will be small.

Indicating Relevant Drawing Change

All ADC's show, in the space marked "Written against—Change Print," the change letter appearing on the drawing at the time when the ADC is written. Thus, the letter *D* appearing in the change-letter space indicates that the ADC affects the *D* change version of the drawing. A copy of this ADC is attached to each regular-issue *D* change print. ADC's written against drawings that do not bear a change letter show a dash in the change-letter space.

Correcting Erroneous ADC

Changes cannot be made on an ADC after its release. Should it be found incorrect, another ADC is issued noting that "This cancels ADC (number)." If additional information must be provided, another ADC is issued, noting that "This supplements ADC (number)." Attempts have been made to assign change letters to ADC reissued with alterations or corrections, but these always ended in confusion and costly errors. In each case the privilege was abused by careless, indolent engineering personnel, resulting in such documentary monstrosities as a *C* change ADC using three colors of hectograph carbon to distinguish among the several changes, with the original information illegible from repeated printing of the hectograph master.

Separate ADC for Each Changed Drawing

A change affecting several drawings requires a separate ADC for each drawing involved. In no case does one ADC relate to more than a single drawing. Several dash numbers on one drawing, however, can be affected by a single ADC. This procedure insures orderly release, recording, and distribution. Release of ADC's affecting several drawings would cause wide variation in the quantity of copies, resulting in confusion and mistakes by Release. The possibility of a multiple ADC being simultaneously incorporated in all drawings affected would be remote, and an ADC might be active against one drawing and incorporated in another.

Effective Serial Number

The production serial number upon which an ADC takes effect is obtained from the manufacturing-planning department except in the case of mandatory changes that must take effect upon a certain unit regardless of disruption of production schedules. In all other cases the desired effective serial number is shown on the ADC when forwarded to Manufacturing Planning for confirmation. If the requested serial number cannot be met without disrupting production schedules, it will be changed by Manufacturing Planning to a satisfactory point. Engineering's selection of a reasonably effective serial number is greatly simplified when Manufacturing Planning uses a block-release system for issuance of shop orders. Thus, all changes within a given calendar period accumulate against the starting serial number of the next production release.

In general, it is not economical to issue ADC's against small drawings, such as the so-called *A* and *B* sizes of 8½ by 11 and 11 by 17. Instead the change should be made directly upon the drawing affected. Exceptions to this rule are emergency ADC's issued by liaison engineers.

Record of ADC's Issued and Incorporated

Whenever an ADC is incorporated in its drawing, the ADC original is marked "Incorporated," with date, change letter, and signature of the person obsoleting the ADC. The obsolete original is then returned to engineering files.

The drawing notice of change accompanying a changed drawing lists the serial numbers of all ADC's incorporated by the change in the "Authority for Change" column (see Chap. 12). This authorizes Release to list the ADC's as incorporated on the status-record cards for the drawing affected. The drawing-status record cards (see Chap. 9) provide for listing all ADC's issued against each drawing as well as a column for indicating the change letter incorporating each. This information is entered by Release, first, when the ADC original passes through Release and later when the changed prints incorporating the ADC are released.

Tool-design Check of Production ADC

It may be found desirable to route all ADC's affecting production models to the tool-design department prior to their release. This will prevent release of ADC's that adversely affect tooling and avail Engi-

neering of information on alternative methods of accomplishing the change at less expense. When this practice is followed, Tool Design checks all production ADC's for effect upon tooling and approves those found satisfactory. Objectionable ADC's are referred to the project engineer in order to arrive at a compromise satisfactory to both the engineering and tool-design departments.

ENGINEERING ORDER

The engineering order (EO) form shown in Fig. 11:6 is used by the engineering department to effect the rapid release of information *not* to be incorporated in a drawing, such as drawing deviations, parts salvage, test instructions, and authorization for manufacture of mock-up parts. Engineering orders are not issued to cover design, material, or dimensional changes, except as temporary or salvage deviations on items not affecting interchangeability. An EO should affect as few units as possible and never be issued to cover large portions of a contract. An ADC should be issued when a quantity of units are involved.

A deviation EO is frequently issued to authorize the rework of parts as a "quick fix" in cases where the actual production drawing change will involve a different alteration of the parts. Parts that deviate from their drawing in a manner that cannot be reworked to the drawing dimensions are often usable. In such cases the parts are not scrapped, and an EO deviation authorizes their acceptance by the inspection department as salvage. As shown in the example in Fig. 11:6, each EO must contain the following information to be complete for release:

Body of EO, Engineering Order No., Dwg. No., Dwg. Title, Model, Effective on, Project No., Dwg. Serial No., Dash No., Written against . . . Change Print, Reason for EO, Disposition of Stock, Signature Block. Information similar or identical with that specified for an ADC.

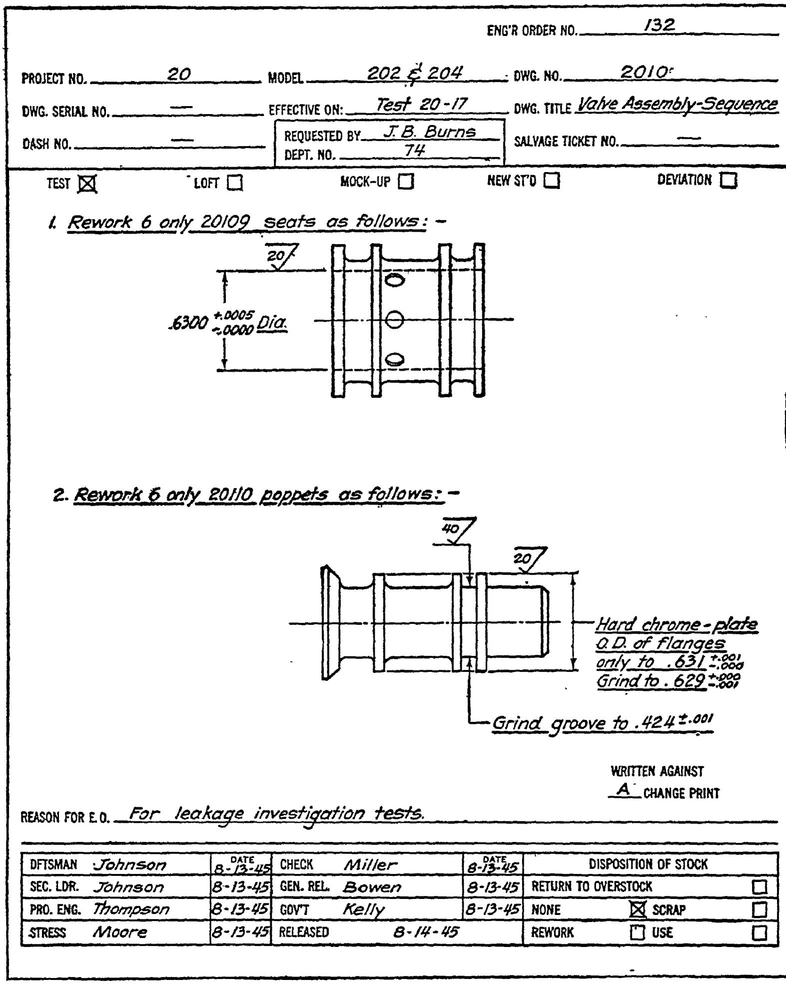
Salvage Ticket No. Serial number of the relevant inspection-department salvage ticket is entered on an EO issued as engineering authorization for use of salvage parts.

Requested by, Dept. No. Name and department number of person requesting EO.

Test, Loft, Mock-up, New Standard, Deviation. Check the applicable square to indicate purpose of EO. A "new standard" EO describes a new standard part or design when there are several divisions of the company, and new standards must be coordinated with all divisions before issuance as a universal company standard (see Chap. 6).

The basic procedure for releasing an EO is similar to that used for ADC's, as shown in Fig. 11:7. The only variation is elimination of Manufacturing Planning as a station in the release system. Engineer-

ing orders do not affect tooling, and the effective serial number is usually based upon actual need for a drawing deviation effective on certain units.



ENG'R ORDER NO. 132

PROJECT NO. 20 MODEL 202 & 204 DWG. NO. 2010

DWG. SERIAL NO. — EFFECTIVE ON: Test 20-17 DWG. TITLE Valve Assembly-Sequence

DASH NO. — REQUESTED BY J. B. Burns DEPT. NO. 74 SALVAGE TICKET NO. —

TEST ☒ LOFT ☐ MOCK-UP ☐ NEW ST'D ☐ DEVIATION ☐

1. Rework 6 only 20109 seats as follows: –

20

.6300 +.0005 −.0000 Dia.

2. Rework 6 only 20110 poppets as follows: –

40

20

Hard chrome-plate O.D. of flanges only to .631 +.001 −.000 Grind to .629 +.000 −.001

Grind groove to .424 ±.001

WRITTEN AGAINST A CHANGE PRINT

REASON FOR E.O. For leakage investigation tests.

DFTSMAN Johnson	DATE 8-13-45	CHECK Miller	DATE 8-13-45	DISPOSITION OF STOCK	
SEC. LDR. Johnson	8-13-45	GEN. REL. Bowen	8-13-45	RETURN TO OVERSTOCK	☐
PRO. ENG. Thompson	8-13-45	GOV'T Kelly	8-13-45	NONE ☒ SCRAP	☐
STRESS Moore	8-13-45	RELEASED 8-14-45		REWORK ☐ USE	☐

FIG. 11:6.—Engineering order.

EO for Test or Mock-up Parts

When an EO is issued to authorize fabrication of a new test part or installation, it is necessary to assign a drawing number to identify the part or installation. The serial number of the EO requiring issuance of the new drawing number is shown in the drawing-number assignment

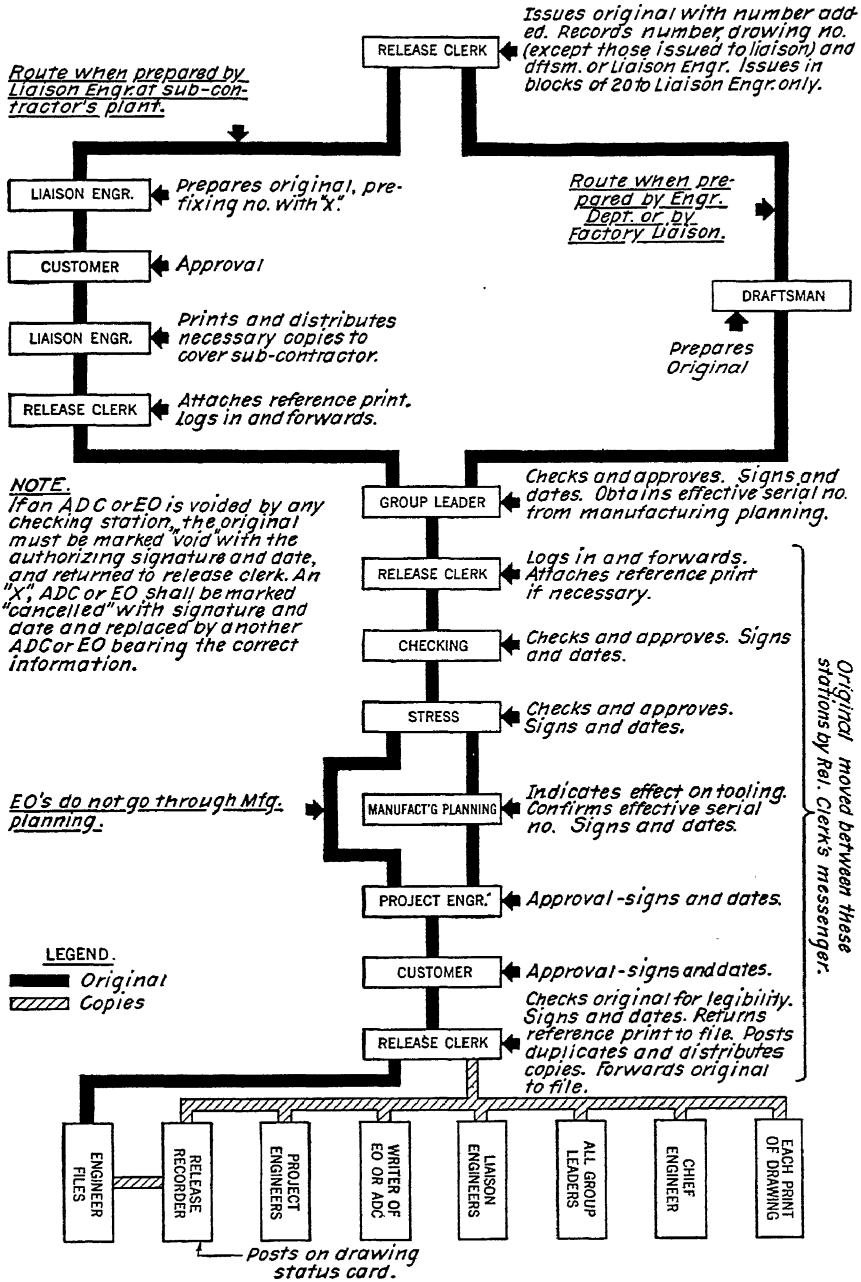


FIG. 11:7.—Release procedure for advance drawing changes and engineering orders.

record. If the test part is found to be satisfactory for production, a drawing or ADC is issued formally to release the part for manufacture. If the test part is unsatisfactory, the drawing number is canceled. When the EO describes an assembly, dash numbers must be used to identify detail parts thereof unless they are described by detail drawings previously released. Dash numbers used for EO part identification are not dash numbers of a drawing and are prefixed with the EO number: thus, "EO—1234-7."

Procedure and Records

The general rules governing advance drawing changes also apply to EO's. The principal difference in procedure for the two documents is the fact that EO's are never incorporated in the drawing and are listed on the drawing-status record cards for reference purposes only. One copy of the EO is attached to each regular-issue print bearing the change letter shown on the EO.

SUMMARY

Efficient distribution of engineering information to manufacturing departments requires mediums that (1) facilitate rapid halting of manufacturing operations, (2) quickly convey drawing-change information to the factory, and (3) provide an expeditious means of issuing approved engineering instructions that do not involve drawing changes but relate to specific parts or drawings.

a. Stop-order and -release, advance drawing change, and engineering-order forms provide the mediums for efficient, rapid distribution of advance engineering information.

b. These forms are 8½- by 11-in. size and preferably for hectograph duplication in order to facilitate rapid preparation of copies. Forms printed on tracing paper for blueprint duplication may also be used but at the sacrifice of ultimate speed in distribution.

c. An approval and release system maintains control of advance engineering information. It is similar to that for drawing release, but concentrated expediting insures that the system time is less than 4 hr.

d. Emergency advance engineering information may be issued by delegated personnel when the need for engineering authorization is so urgent that the 4-hr. system time cannot be tolerated and when the emergency arises outside the engineering department's normal working hours.

e. Records insure that copies of all active advance engineering information releases are attached to all prints of the drawings affected.

f. All active advance drawing changes are incorporated in the drawing affected either (1) during the next routine drawing change or (2) when the quantity of ADC's becomes sufficient to cause difficulty in properly interpreting the drawing.

g. Engineering orders are never incorporated in a drawing change.

CHAPTER 12

DRAWING CHANGES

Drawing changes are undesirable but equally unavoidable. It is impossible to foresee all conditions that will be encountered during manufacture of a product, and production-improvement changes will be required during fabrication and assembly. Other changes originate from engineering errors during initial preparation of drawings. Unsatisfactory operating conditions experienced by customers often require design changes, and in the case of contracted articles the customer's requirements may alter during the life of the contract.

The necessity of expending engineering time on drawing changes through the production life of a product must always be considered in planning the operation of an engineering department. A small department, employing five or six draftsmen and engaged in the design of moderately complex equipment, should plan on one to two draftsmen devoting their entire time to production drawing changes. A large engineering department, engaged in design of highly complex products, will need considerable personnel for drawing changes. For instance, one leading manufacturer of four-engine bomber aircraft (having an engineering department of approximately 1,800 employees) found that 136 persons were required to handle the average of 350 drawing changes necessary during each week of this model's production.

Another prominent aircraft manufacturer bases his engineering planning on the premise that the time expended upon drawing changes after production begins will approximately equal the engineering time required to complete the original design. A surprising quantity of changes are also necessary during translation of an experimental prototype into a production design. An actual case of a twin-engine night-fighter airplane produced by a western manufacturer shows that for a total of 4,857 drawings there were required 4,727 actual drawing changes and 3,787 advance drawing changes (see Chap. 11) during the production-engineering phase.

In any case it is certain that drawing changes are a normal phase of engineering-department operation and that it is necessary to establish

an orderly method of making and recording these revisions. Drawing-revision methods are primarily concerned with (1) drawing-change request procedure and (2) drawing-change system. The first consideration involves establishment of a method that insures prompt action on all changes requested by other departments. The second requires establishment of a logical, efficient method of preparing and identifying drawing revisions.

DRAWING-CHANGE REQUESTS

Drawing changes are requested for a variety of reasons, but a majority can be grouped into three broad classifications of revisions: (1) to correct engineering error; (2) to reduce cost, facilitate production, and/or simplify manufacture; and (3) to improve the serviceability of the product. Change requests may originate with the customer, subcontractors, other departments of the company, or engineering-design groups desiring changes on drawings controlled by another group.

Revisions desired by the customer are usually requested through the sales or contract departments either by correspondence or by special procedure established by the customer. All drawing-change requests originating within the engineering department, in other departments of the company, and from subcontractors should be handled by a drawing-change request form (CR), similar to that shown in Fig. 12:1. This provides the following information:

Dwg. No. Number of drawing to be changed.

CR No. Change-request identification number.

Dwg. Title. Exact title of drawing to be changed.

Date. Date when CR was prepared.

Zone. Identifies location of change on large drawings provided with zone markings.

Nature of Change. Concise description of change, sufficiently complete to permit decision without referring to originator for additional information. When immediate action is necessary, the CR should note that an advance drawing change is desired.

Specific Reasons for Change. Complete, detailed reason for requesting change.

Requested by, Department, Date, Supervisor, Date. This block provides for name and department number of originator, date of request, and approval of originator's supervisor.

Inspection. Used by inspection department to approve or reject requests originating in manufacturing departments.

Planning. Used by manufacturing-planning department to approve or reject requests originating in manufacturing departments.

Release, Group Leader. Used by Engineering Release to record date when CR is received, forwarded to relevant engineering group leader, received from group leader, and copies distributed by Release.

Engineering Action. Used by relevant group leader and project engineer to indicate nature of engineering action on request.

Reason for Rejection. Used by Engineering to indicate reason when request is found undesirable and rejected.

DRAWING No. 25232 C. R. NO. D 0077

DRAWING CHANGE REQUEST

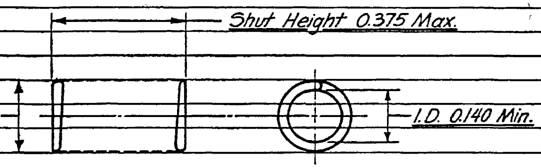
DWG. TITLE: Spring—2½ GPM Selector Valve Thermal Relief DATE 7/9/45

ZONE

NATURE OF CHANGE

DESCRIBE CHANGE REQUIRED IN DETAIL. GIVE ALL PERTINENT INFORMATION AND PRECISE REASONS FOR CHANGE. MAKE SKETCH ON THIS FORM TO CLARIFY REQUEST IF NECESSARY.

Change thermal relief valve springs to dimensions shown below:—



Mat'l—Music Wire. 12¼ Lbs. ±¼Lb. at 0.437 Compressed Length

Note: ADC requested

SPECIFIC REASONS FOR CHANGE: Current production spring is too strong, causing thermal relief adjustment to be highly critical

REQ. BY L.E. Cuttle
DEPT. Inspection DATE 7/9/45
SUPERVISOR L.E. Cuttle
DATE 7/9/45

INSPECTION
APPROVE ☒ REJECT ☐
BY L.E. Cuttle
DATE 7/9/45

PLANNING
APPROVE ☒ REJECT ☐
BY T.R. Lynn
DATE 7/10/45

RELEASE	GRP. LDR.
7/11/45 IN	Haines 7/11/45 IN
7/14/45 OUT	7/13/45 OUT

ENGR. ACTION
APPROVE ☒ REJECT ☐
ADC NO. 435
STOP OR. NO. —
DWG. CHG. BY: — (DATE)
DES. GRP. ☐ CHG. GRP. ☐
GRP. LDR. H. M. Haines
DATE 7/13/45
PRO. ENGR. C. A. Jones
DATE 7/13/45

REASON FOR REJECTION

FIG. 12:1.—Drawing-change-request form used to request drawing revisions.

The detailed processing of drawing-change requests is shown in Fig. 12:2 for the engineering department of a self-contained company and for requests affecting drawings controlled by the originating division.

engineering department. When the company has two or more operating divisions, it may be necessary for one division to request changes on drawings under control of another division. This involves a slightly

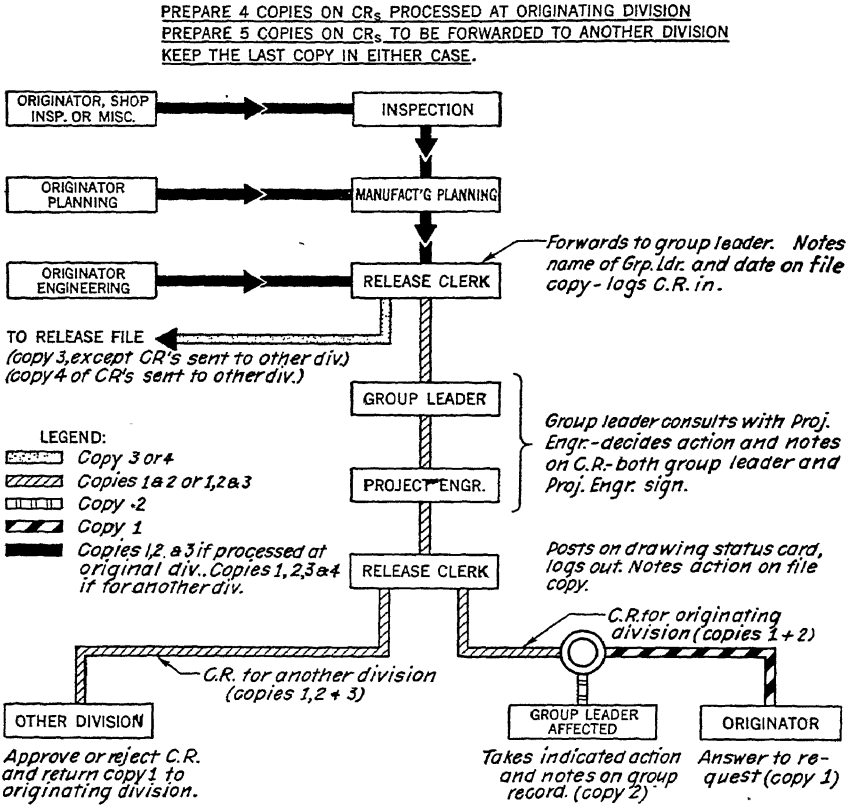


FIG. 12:2.—Routing of drawing-change requests for self-contained organization, or those originating in division controlling affected drawings.

different procedure, which is illustrated in Fig. 12:3. In all cases the basic routing for CR's is

a. Originator
b. Inspection department (manufacturing-department requests only, for review)
c. Manufacturing-planning department (manufacturing-department requests only, for review)
d. Engineering release (for recording and routing)
e. Project engineer and engineering group leader (for investigation and disposition)
f. Engineering release (for recording and distribution)
g. Originator (notification of engineering action)

Origin of Change Requests

A change request may originate with any department but does not receive recognition until delivered to Engineering Release for recording and engineering investigation. Some engineering departments consider it advantageous to route all CR's through Engineering Planning and then to Release, followed by routing from Release to Planning for distribution of the copies showing engineering action. This provides Planning control over all work originating from change requests. The CR form (see Fig. 12:1) is prepared as an original and three carbon copies, except that CR's forwarded to another division of the company require four carbon copies. The original and all except the *last* copy are routed as shown in Figs. 12:2 and 12:3. The last copy is retained by the person originating the request.

All CR's originating in manufacturing departments are signed by the person requesting the change, endorsed by the originator's immediate superior, and then routed to the inspection department for approval. Inspection will either approve or reject. If the CR is approved, all forwarding copies of it are routed to Manufacturing Planning. If it is rejected, a statement of the reason for rejection is placed on the back of all copies, followed by routing to Manufacturing Planning. Planning will either approve and forward to Engineering Release or reject and forward with a statement of the reason for rejection. This procedure provides Engineering with the viewpoints of Inspection and Manufacturing Planning and insures that all requests originating in manufacturing departments reach Engineering.

Change requests should be used within Engineering only when one design group desires changes upon a drawing within the control of another design group; they are *not* necessary for changes within the group. Liaison engineers use this form to request changes to facilitate production, investigate engineering errors, and the like. The request is prepared by the person desiring the change, endorsed by the originator's immediate supervisor, and then forwarded to Engineering Release or Planning (as the case may be) for routing.

Routing Requests Through Engineering

Engineering Release, upon receipt of a CR, detaches the third copy and files this in an "incomplete CR file" as a record of receipt and subsequent routing. The remaining copies are routed to the relevant group leader, with suitable notations of date and name entered on the release file copy. The remaining copies (one and two) of the CR are returned to

Release for distribution after engineering investigation is complete. The original copy is returned to the originator of the CR, and the second copy is sent to the group leader. Suitable entries on the release file copy indicate the date of this distribution. All approved change requests are posted on the drawing-status record card or cards affected (see Chap. 9), and the release file copy is placed in an "approved CR file." Disapproved CR's are filed in an "obsolete CR file."

Engineering Investigation of Change

The relevant group leader determines the action required by the CR through consultation with the project engineer affected. Final engineering approval or rejection is entered in the "Engr. Action" block and bears the signatures of both group leader and project engineer. The action taken on each approved change request will be issuance of an advance drawing change (ADC), issuance of a stop order, or preparation of a drawing change.

An advance drawing change should be issued when the CR requires immediate action. When the change requested involves extensive investigation and appears sufficiently serious to warrant halting manufacture until the investigation is complete, a stop order may be issued. This practice, however, must be used with discretion, and an effort made to release the stop as soon as possible for mere issuance of a stop order does not satisfy the request for change. When the change request is justifiable but does not require immediate action, it can be answered by filing the CR for incorporation as part of the next change on the drawing.

Engineering Action

The block at the bottom of the change request marked "Engr. Action" is used to notify the requester of the action to be taken by engineering. If the request is rejected, it is necessary only to check the "Reject" square and note the reason for rejection in the space provided. If the request is approved, the square marked "Approve" is checked, and the engineering action indicated on one of the three lines below. If an advance drawing change is being issued, its number is noted. When a stop order is issued, its number should be noted. If neither an ADC nor a stop order is being issued and the request will be handled by a drawing change, then the estimated date of the change is noted on the line provided. When a change group exists, it is necessary to note whether the change will be made by that group or by the design group affected. Do not fill in more than one of the three lines provided for indication of action on approved change requests.

Regardless of the final action, the CR must bear the signature of both project engineer and group leader affected before final distribution. An approved change request covered by an ADC or a stop order should not be distributed until that document is actually released. The coordination required to effect simultaneous release of approved CR and relevant advance engineering information is a responsibility of the release group.

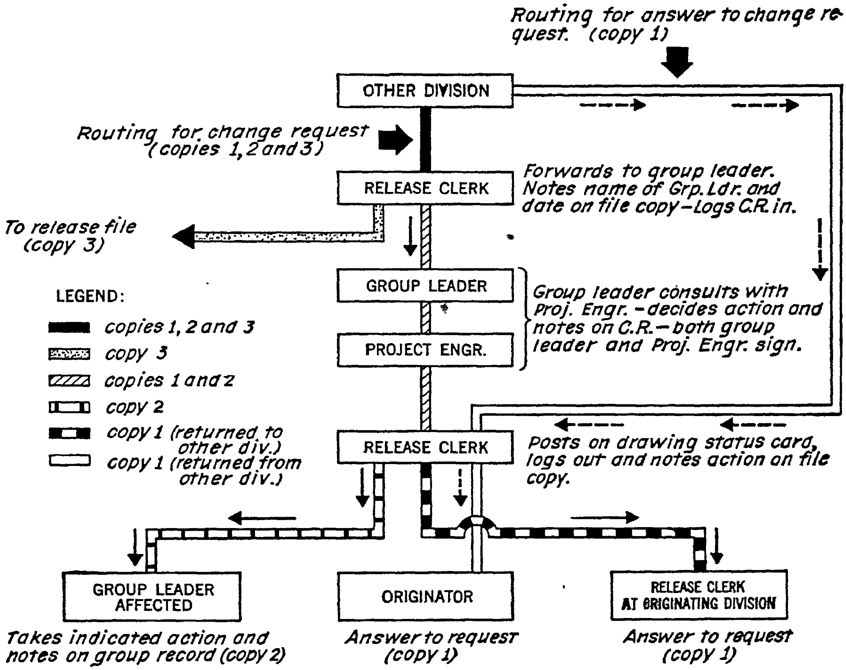


FIG. 12:3.—Routing of drawing-change requests received from another division.

CHANGE-REQUEST RECORDS

Records of the issuance, approval or rejection, and incorporation of change requests are maintained by the engineering release group. An "incomplete" file contains all requests upon which action is pending, and an "approved" file contains a copy of each authorized request. A copy of each rejected change request is placed in an "obsolete" file.

The drawing notice of change accompanying a changed drawing lists in the "Authority for Change" column the serial numbers of all change requests incorporated by the revision. This authorizes Release to list the CR's as incorporated on the status-record cards (see Chap. 9) for the drawing affected. These drawing-status record cards provide for

listing all CR's issued against each drawing as well as a column for indicating the change incorporating each. This information is entered by Release, first, when the approved CR is distributed and later when the changed prints incorporating the CR are released.

Changes on Drawings at Another Division

When changes are desired upon drawings in the possession of another division, a change request should be written in the normal manner. This CR is routed to obtain the usual signatures, but the noted engineering action is "Dwg. change by (name of division)." The original, duplicate, and triplicate copies of the CR are forwarded by Engineering Release to the division affected by the request. The fourth copy (made only for CR's sent to another division) is filed by Release at the originating division). The other division handles these CR's in the normal manner, returning the original copy to Release at the originating division.

CHANGE REQUESTS FROM SUBCONTRACTORS

All change requests from subcontractors should be plainly marked "Subcontractor—CR" on each copy. Change requests originating with a subcontractor are prepared as an original and four carbon copies. The original and three copies are routed to the prime contractor. The last copy is retained by the subcontractor. These change requests should be approved by the subcontractor's engineering department, followed by routing to the prime-contractor liaison engineer at the subcontractor's factory. The liaison engineer examines the change request and writes his comments on the back of all copies. The original and three copies of the change request are then forwarded to Engineering Planning at the prime contractor's plant.

If the requested change demands immediate action, the liaison engineer may issue an emergency ADC or EO, as described in Chap. 11, before forwarding the change request. This action is noted under the liaison engineer's comments, and a copy of the emergency ADC or EO is attached to each copy of the change request. The CR number must appear on the ADC or EO. Small subcontractors, without a resident prime-contractor liaison engineer, forward these change requests directly to Engineering Planning at the prime contractor's plant.

Engineering Planning records the change request as part of its function of handling all requests originating outside the company and forwards all copies to Engineering Release. These subcontractor CR's are processed in the normal manner, except that the original copy is returned

to the originator through Engineering Planning (and prime-contractor resident liaison engineer) and the *third* copy is delivered to the liaison engineering supervisor.

DRAWING CHANGES

A definite procedure for handling drawing changes is necessary in order to insure efficient, accurate revisions. The following general method for processing drawing changes is used by many engineering departments, and the detailed instructions contained in this chapter are based upon this system.

a. Group leader assigns change to draftsman.

b. Draftsman obtains affected drawing from engineering files and checks with Release to obtain a list of all unincorporated ADC's and change requests.

c. Draftsman ascertains if change will affect interchangeability. Changes that do require special handling.

d. Required revisions are made, including incorporation of *all* outstanding ADC's and CR's, in addition to changes requested by the group leader and approved by the project engineer. A change letter is assigned to identify the revision.

e. Change is recorded in the drawing title block.

f. A notice of change is prepared, describing the change accomplished.

g. The drawing, notice of change, copies of all ADC's and CR's incorporated, and other reference data are returned to the group leader.

h. The group-leader inspects the change and signs the notice of change if the work is approved. Group leader then writes a release request covering the drawing affected and forwards request and drawing with all reference data to Release.

i. Release places drawing in release system for checking and approval.

j. Draftsman makes required checker's corrections.

k. Corrected and approved drawing is released, and prints distributed.

Incorporation of ADC's and CR's

Whenever a drawing is changed, it is necessary to dispose of *all* outstanding CR's and ADC's. Some outstanding ADC's may have been canceled by others, but all should be listed on the notice of change—even those found undesirable and not incorporated in the change. These are disposed of by a note on the notice of change as being "Canceled by this change." When one ADC has been superseded by another, both must be listed on the notice of change as the only means of clearing the record of ADC's is to list them on a notice of change. An effort should be made to prevent accumulation of large quantities of ADC's against a drawing. In general, the drawing should be changed to incorporate outstanding ADC's when more than 10 accumulate.

CHANGES AFFECTING INTERCHANGEABILITY

When a change is made affecting interchangeability or to modify the part for increased safety, it is necessary to have two drawings available for the part involved: one for the original part and one for the new design. Both drawings must remain active in order to permit ordering and manufacture of spare parts and must carry "service-data" notes to indicate the effective serial numbers of each. There must be *actual drawings* for both old and new parts. These may be a duplicate tracing for the old part and the original drawing changed for the new or a new tracing prepared for the new part. *If the change is retroactive to cover all units and spare parts*, it is unnecessary to add service-data notes to the drawings, and a cancellation notice of change is sufficient for the old drawing. In these cases an effective serial number for the production change point is determined and listed on the notice of change, together with a notation that "All prior articles to be reworked per Service Bulletin (number)." See Chap. 13 for additional information on service bulletins.

Place the following note on the old drawing and assign the next change letter to cover the addition of the note.

SERVICE DATA

THIS PART USED ON (model) UNITS (serial no.) THROUGH (serial no.) ONLY. REFER TO (dwg. of new part) FOR SUBSEQUENT UNITS

Place the following note on the drawing of the new part:

SERVICE DATA

THIS PART USED ON (model) UNITS (serial no.) AND UP. REFER TO (dwg. of old parts) FOR PRIOR UNITS

These service-data notes should be located to the left of the drawing title block, except that *A*-size ($8\frac{1}{2}$ by 11 in.) drawings carry the note above the title block.

If the change also creates two noninterchangeable forms of the next assembly, it is necessary to place similar service-data notes on these. Follow the change through subsequent next assemblies with service-data notes on each until a point is reached where interchangeability is no longer a factor. Upon the first next assemblies, which may use either

version interchangeably, call for both new and old versions as a dual part call-out. Thus:

(Old part no. and name) X REQ—(serial no.) THROUGH (serial no.)
(New part no. and name) X REQ—(serial no.) & UP

It is not necessary to give complete information at the call-outs, such as model designations, for these data can be obtained by reference to

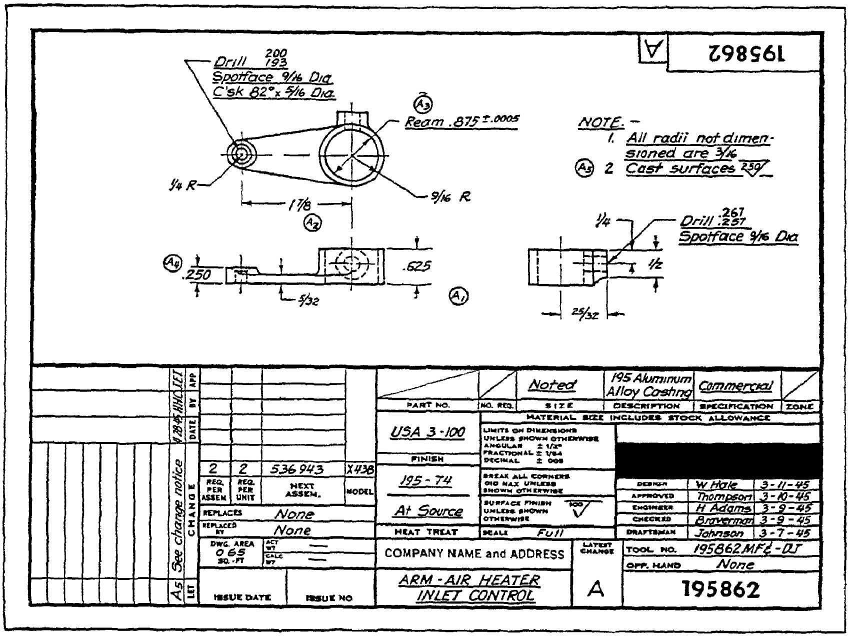


FIG. 12:4.—Changed drawing, showing use of change symbols and change-letter subnumerals.

drawings of the parts involved. This procedure must not be confused with coding a drawing in order to permit its use with minor variations upon another model but relates only to changes affecting interchangeability during the production of a model.

CHANGE LETTERS

Each successive drawing change is identified by a letter, beginning with *A* for the first change and continuing in alphabetical order, except that the letters *I*, *O*, *Q*, *R*, and *X* are not used. Deletion of these letters eliminates the possibility of confusing change letters with numerals 1

and 0, the radius symbol, and the multiplication sign. Each item of a change is identified by a symbol comprising the change letter enclosed with a $\frac{5}{16}$-in. diameter circle placed adjacent to the affected portion of the drawing. When a change involves more than one item, subnumerals are added to the change letter to identify each item (such as A_1, A_2, A_3) (see Fig. 12:4).

Some engineering departments identify drawing changes by numerals rather than letters. Thus, the *A* and *B* change versions of a drawing would become the 1 and 2 revisions. However, it appears that a majority prefer the change-letter method.

Drawing Title Block

The change letter, with the highest subnumeral of the change, is entered in the drawing title-block revision record space. The date of the change and the name of the draftsman are entered in columns provided for these data. The government representative usually signs in the "Approval" column when the drawing relates to government contracts.

Use of a notice of change eliminates need for describing the change in the title-block revision space, which ordinarily does not provide sufficient area to describe the revision adequately. The identical deficiency is usually present even in cases where the drawing-revision space is separate from the title block. Some companies use a drawing title block that provides only for listing the change letter together with date and signature columns. An instruction to "See notice of change for details" forms a part of the title-block revision space.

Notice of Change

The notice of change accompanying a changed drawing must be carefully prepared. Its purpose is to indicate what change has been made, which ADC's and CR's are incorporated in the change, what is to be done with the stock (in work or stores) of existing parts, and when the change becomes effective. It should also provide a clear record of the drawing's appearance prior to the change. Many changes become effective during a project, with the result that some parts must be fabricated according to the drawing *prior* to the change and others *according to the change*. Thus, the drawing and attached notice of change should clearly set forth complete information for both old and new parts.

The complexities of mass production require that the notice of change accompanying a revised drawing provides a variety of information to guide the manufacturing-planning department in applying the change.

The information required makes impractical the use of a revision space in the title block or upon the drawing. That method is suitable for job-shop work where only a few units are involved and additional information can be supplied by verbal instructions. Attempts to use this method on production drawings will either result in confusing the field of the drawing with a mass of change information or condensing the revision data to a point where it becomes inadequate for production purposes. Use of a separate notice of change is advisable for all production drawings.

The notice of change shown in Fig. 12:5 is an 8½- by 11-in. form printed on tracing paper and provides the following information:

Heading of Form. The information required in the spaces at the top of the form is obvious upon inspection. The "Job No." space is used by Release to enter the job ticket number when the change is placed in the system.

Letter No. Enter here the subnumerals of the various change items, but use 1, 2, 3, etc., rather than the A_1, A_2, A_3, etc., used on drawing.

Zone. Show here the drawing zone in which the change appears. Used only for large drawings.

Kind of Change. Show here the essential nature of the change in order to permit ready identification of each change item. Examples of entries in this column are:

Add service data	Increase cutout
Remove rqmts.	Change hole pattern
Change h. t.	Add coding
Change mat'l.	Change picture
Add holes	Remove pilot holes
Remove tricleats	Add brackets

Detailed Description of Change. In this space, state clearly and concisely what was done.

Effective on. Show the effective production serial number for each change item. These should be the same as shown upon ADC's incorporated in the change. Effective serial numbers for new items not previously covered by ADC's should be verified with manufacturing planning.

Authority for Change. Enter here the ADC or CR number authorizing the change. Should the change be one originating within a design group (for which no CR or ADC would exist), the abbreviation "Engr" will be entered in the "Authority" column. Use applicable name for customer-request changes in addition to ADC numbers.

Disposition of Parts in Stock. Enter here the stock disposition for each change item. There are five normal conditions of stock disposition, namely, "Use," "Rework," "Scrap," "Return to overstock," and "None."

Reason for Change. Enter here the essential reason for each change. If several reasons exist, show the letter numbers relating to each reason.

Affects Dash Numbers. Enter here a record of all dash-number parts affected by the change.

Signature Block. Provides for signature and date by each person processing drawing change.

Extensive Drawing Revisions

When extensive revisions are made in a large drawing, it may be found that several pages are required for the complete notice of change. Changes of this nature become so involved that Manufacturing Planning usually finds it desirable to process the change as though it were a

NOTICE OF CHANGE

Dwg. No. 195862
Chg. Letter A
Model X 438
Date 4-28-45

Contract No. NX(s)1053
Project No. 32
Job No 32-1231
Sheet No. 1 of 1

Title Arm-Air Heater Inlet Control

Letter No.	Zone	Kind of Change	Detail Description of Change	Effective on	Authority for Change	Disposition of Parts in Stock
1		Finish	Disc grind note removed	707 & up	CR-1356 &	Rework
2		Dimension	1-7/8 was 1-3/4.	707 & up	ADC-2735	Use
3		Tolerance	Ream note added	707 & up	↓	Rework
4		Tolerance	.250 was 1/4	707 & up	↓	Rework
5		Finish	Cast surfaces 250 √ note added.	707 & up	Engr	None

REASON FOR CHANGE:
1 - .625 dimension could not be held by disc grinding
2 - Engineering error. 3 & 4 - Interference at assembly.
5 - To clarify drawing.

Affects Dash Numbers None

Shop	4-21-45	H. Adams	4-28-45	W. Jones	4-30-45	J.E. Thompson	5-1-45	W. Hale	5-2-45	M. Roberts	5-3-45
Requested By	Date	Group Leader	Date	Stress	Date	Project Eng.	Date		Date	Blueprint	Date
H.H. Cooke	4-28-45	G. Braverman	4-29-45	R. Harvey	4-30-45	—		R. D. Ray	5-3-45	—	—
Changed By	Date	Checked By	Date	Weights	Date	Parts List	Date	Release	Date		

Fig. 12:5.—Notice of change used to provide complete information on drawing revisions.

new drawing rather than attempt to correct the records for each individual change item. Furthermore, the printing and distribution of extensive notice of change are expensive and serve no useful purpose. In actual practice it is wise to limit multipage notice of change to a maximum of six pages.

When more than six pages are required for the complete notice of change, two separate notices should be prepared, each bearing the same change letter. One is complete, listing every change item, and is prepared only for record purposes. The second notice is distributed with copies of the changed drawing and does not list the change items but simply states "Drawing Completely Revised." Both notices accompany the drawing through the release system, but, after the drawing completes the system, the complete notice is detached by Release and

forwarded to Engineering Files. The second, single-page notice accompanies the drawing to Blueprint for preparation of copies for distribution with the drawing prints. The complete notice is always available for reference, and the wasteful distribution of an extensive notice of change is avoided.

Printing and Filing Notices of Change

The current notice of change should be blueprinted adjacent to the right-side edge of the drawing, and a copy of it accompanies each print. This method eliminates all possibility of the notice becoming detached from the print, for the reproductions of drawing and notice are on the same piece of blueprint paper. Use of staples or other mechanical means of attaching the notice to the print should be discouraged, for not only is more time required, but the hazard of the notice's becoming detached is always present.

The current notice of change should be filed with the drawing at all times. Obsolete notices should be stored in the engineering files.

Drawing Cancellation

A notice of change written to cancel a drawing should always state whether or not the canceled drawing is replaced by another. One of the following notes should appear:

CANCELED—REPLACED BY (XXXXX)

or

CANCELED—NOT REPLACED

New drawings that replace existing drawings should carry the note "Replaces (old dwg. no.)." A space is provided for this purpose in the title blocks recommended in Chap. 8. Otherwise the drawing should carry this information as a general note, adjacent to the title block.

Changes on Duplicate Tracings

Duplicate tracings, such as direct-line transparents, of drawings in the possession of another division cannot be changed. If a revision is necessary, a change request should be forwarded to the division in possession of the original drawing, and action upon the requested change must await return of the acknowledgment copy of the change request.

Changes on Drawings Comprising Two or More Sheets

A drawing comprising two or more sheets should be considered as a single drawing. Its zone numbers should be continuous from sheet to sheet, not duplicated on succeeding sheets. Also the title-block change spaces should be filled out in an identical manner on all sheets, and the current notice of change should be printed with each sheet of the drawing. The notice of change should always be made for the drawing as a whole, not written against individual sheets of the drawing. Unless this practice is followed, there will exist a confusing condition of having different change letters for separate areas of the same drawing.

SUMMARY OF DRAWING-CHANGE PROCEDURE

All drawing changes can be grouped into eight classifications, and definite rules can be established for proper handling of the old and new drawings involved in each case. The statements appearing in quctes in the summary on pages 243 and 244 should be used verbatim on drawings and notices of change in order to provide simple, positive identification of the class of change.

CHANGE GROUP

Some engineering departments have established change groups for the purpose of relieving design groups of the burden of routine changes. In theory this arrangement should prove very satisfactory, but in practice the reverse is usually true. The resultant decentralization of drawing control often introduces drawing-change errors that do not occur when the design group leader retains complete control over all drawings relating to his work. This condition is further aggravated by the tendency to consider the change group as a training center and to staff it with inexperienced draftsmen.

Duplication of effort is frequently experienced when a separate change group exists, resulting from the design group leader making design changes just before or immediately after a routine incorporation of ADC's and CR's by the change group. Both could have been accomplished by a single drawing change. Although this is admittedly a problem of coordination, it is also apparent that it would not exist in the absence of a change group.

The logical conclusion drawn from experience with many change groups is that more efficient utilization of personnel can be accomplished by placing junior draftsmen in each design group for the express

Old drawing	New drawing	Remarks
Class I. *Advance Drawing Change:*		
Changes requiring immediate action can be economically and rapidly made by use of an ADC. Do not use for *A* and *B* drawings without approval	....	....
Class II. *Detail Change:*		
All changes involving revisions and additions *without redrawing.* Place date, name, and change letter in the title-block space	....	Write notice of change, assign change letter, and list changes
Class III. *Void:*		
(Drawings that have not been released)		
No notice of change required. Group supervisor writes "Void" on margin of drawing below title block with date and signature, draws two red lines through number, and forwards to Files for storing with obsolete tracings	....	Check next assembly, and remove requirements for part. Notify numbers clerk
Class IV. *Canceled—No Longer Used:*		
(Drawings that have been released and are no longer required)		
Write notice of change, giving reason for discontinuing part and listing as canceled all ADC's against the drawing. Place change letter in title block, and cross out with a neat *X* that leaves the letter legible. Draw two red lines through Dwg. No. in title block, and write "Canceled" below number, with date and signature	....	Must not affect interchangeability. Give detailed "reason" explanation. Remove part from next assembly with change or ADC. Notify numbers clerk
Class V. *Superseded:*		
(Drawings that have been released and later replaced by a noninterchangeable part)		
Remains active with "Service Data" note added to dwg. Notice of change required	Service-data note required	Applies to changes involving interchangeability. Notify numbers clerk

[*Continued on next page*]

Old drawing	New drawing	Remarks
Class VI. *Redrawn—Same No.—No Change:* No notice of change but change letter in block and notation in "Change" space. Cross out change letter and Dwg. No. as with Class IV change. Write "Redrawn—Same No.—No Change" below number, with date and signature	Write notice of change, and note change in size, if any. Same change letter is used on both old and new drawings	Does not affect interchangeability
Class VII. *Redrawn—Same No.—With Changes:* No notice of change. Cross out change letter and Dwg. No. as in Class IV change. Write "Redrawn—Same No.—With Changes" below number with date and signature	Same procedure as Class VI preceding	If next assembly is affected, correct by drawing change or ADC
NOTES ON REDRAWING *a.* Copy (do not imitate) all signatures, printing them exactly as they appear on the old drawing. *b.* Do not copy previous change letters, either on the face of the drawing or in the change block. *c.* Indicate the new changes, forming the revision being made, in the conventional manner, and list in the notice of change. *d.* Always use full name for signature (not initials).		
Class VIII. *To Reinstate a Voided or Canceled Drawing:* Assign next change letter. Write notice of change, stating "Reinstated" and explain reason Remove *X* from cancellation change letter, red lines from Dwg. No., and cancellation note below number	. . . .	Same as Class VII. Notify numbers clerk. Additional change items may be listed on the "reinstating" notice of change

purpose of accomplishing routine changes. These can be placed under the direct supervision of a senior draftsman, who then acts in the capacity of assistant group leader. The actual delegation and final approval of all work remains under the control of the design group leader, and his centralized control is maintained over drawings related to the design group's work.

CHAPTER 13
TECHNICAL SERVICES

A variety of services is required to support and augment the work of engineering designers and draftsmen. Those services that require specialized technical knowledge and do not directly involve product design or drafting can be classified as *technical services.* A majority of technical services is required to supply specialized assistance in solving problems encountered in product design but in a few cases to implement operation of the engineering department. Engineering planning, cost control, patent research, and handbooks are in the latter classification.

Among the more important technical services required for the successful operation of an engineering department are (1) planning, (2) cost control, (3) standards, and (4) patents. They have received detailed consideration in preceding chapters and do not require repetition. In addition to these functions, the following technical services are needed to complete the technical implementation of engineering activities:

Lofting	Laboratory	Service bulletins
Materials	Specifications	Customer service
Processes	Handbooks	Illustration

In a small engineering department it may be necessary for one person to handle several of these services. Large engineering departments usually have a supervisor with suitable personnel assigned to each technical service.

LOFTING

Lofting is an important service in all engineering departments engaged in the design of products requiring developed surfaces. The design groups prepare drawings showing the finished shape of the manufactured parts. The lofting group develops the true shape of the article and supplies the tooling department with information for templates, form blocks, and dies.

The lofting function is of greatest importance to engineering departments engaged in the design of airplanes, ships, and automobile bodies but can also be of assistance in the design of many smaller articles involving a contoured sheet metal exterior—particularly where the exist-

ence of compound curves requires the fairing of lines. The work of the loft group begins immediately after preliminary design of the article, during which the major dimensions and a basic envelope for the article are determined and an accurate small-scale drawing of the completed article is prepared to show its external configuration. During preliminary design the basic structure is also determined and located.

The preliminary design work is accomplished in close cooperation with the loft group, and lofting begins as soon as the external configuration and major structure are determined. A full-size body plan is prepared, together with full-scale transverse sections of all important body "stations." Horizontal sections (water lines) and longitudinal sections (buttock lines) are prepared as necessary to fair the body plan completely.

The basic loft lines are prepared as close to plus-or-minus zero limits as it is possible to work, and in general practice the lines are held within limits of ± 0.010 in. These basic lines are used for the preparation of all subsequent loft layout boards and may be scribed directly into wood or drawn upon metal sheets with a pencil or stylus. Detail loft boards, which accurately establish contours for structural assemblies, are prepared by transferring the basic lines of the required section from the master layout to a detail loft board. After the basic lines are transferred to the detail board and checked for accuracy, the structural members involved are carefully drawn in position upon the detail board. This practice of transferring lines from the master layout to detail loft boards permits simultaneous preparation of a variety of detail boards, all based upon information obtained from the full-size master layout.

Lofting can furnish the designers and draftsman with accurately developed lines for any section of the article and thus eliminate the necessity of time spent by engineering personnel to develop the true shape of sections affecting their work. Furthermore, as all designers and draftsmen are working from the same basic information, the possibility of error is much less than when each engineer prepares his own development of surfaces and sections affecting his work.

The tool-manufacturing department obtains from the loft boards the information required to manufacture assembly fixtures, templates, match plates, and other tools. Lofting also relieves the tool department of the necessity of preparing full-size layouts of parts drawn to reduced scale. When a mock-up must be prepared, in wood and plaster, of all or part of the complete article, it is guided by the lines and layout prepared by the loft. In most cases the supervision of mock-up work is assigned to the loft group to insure that the completed mock-up accurately represents the proposed article's true form.

MATERIALS

Selection of the proper material for a given part is an important consideration in every design. Not only must the material be suitable for the usage, but it is necessary to determine the most economical material to perform the required function without compromising safety and service life. The material selected must be one that can be obtained in the required raw-stock form in time to meet production schedules. This technical service is so important that practically every engineering department should have the functions of "materials engineer" definitely assigned to one person. In a small department this can be made a responsibility of the standards engineer, but larger departments will require the full-time services of a competent person to care for materials problems adequately and efficiently.

The materials engineer should maintain an index of material specifications, issued to all design and drafting personnel as a list of materials approved for use on manufacturing drawings. Usage of other materials requires approval of the materials engineer. All commercial and purchased parts should be approved by the materials engineer prior to their initial usage. This insures that the proper purchased parts will be specified on drawings and avoids both procurement of unnecessarily expensive purchased items and usage of dubious items that may lead to service difficulties. The materials engineer is also responsible for maintaining current information on all known sources of material and the availability of various forms and shapes of raw-stock material.

One of the problems encountered during the development engineering phase of a new article is ordering the required material early enough to insure that it will be in stock when required for construction of the first experimental article. Early ordering of materials needed for experimental articles can be accomplished by an "advance engineering material order" procedure, using the form shown in Fig. 13:1.

Advance Engineering Material Order Procedure

An advance engineering material order (AEMO) is prepared in quadruplicate by the materials engineer as soon as the design of an installation or main assembly crystallizes to a degree where a majority of the materials required can be accurately estimated. The materials engineer then obtains approval of the engineering supervisor and project engineer concerned, retains the original copy of the AEMO, and forwards the three carbon copies to the engineering-release group. Release files the quadruplicate copy, forwards the triplicate to the engineering

supervisor concerned, and dispatches the duplicate copy to the material-control group of Manufacturing Planning.

Material Control investigates the availability of the material and, if it is found to be in stock, enters "Allocated" opposite the affected item on the AEMO. The material involved is then "frozen" in raw-stock stores for use only on the project affected. If the required material is *not* in stock, a purchase requisition is originated by material control, and the requisition number together with the specified delivery date is entered on the material-control copy of the AEMO. The AEMO number is entered on the purchase requisition.

When the purchasing department places an order for the material specified in the purchase requisition, a copy of the purchase order (noting the AEMO number and guaranteed delivery date) is forwarded to Material Control, who then records the purchase-order number on the related AEMO and checks the guaranteed delivery date against the required date. If the actual delivery date is found unsatisfactory, the materials engineer is notified; he in turn informs the project engineer and engineering supervisor concerned so that appropriate action can be taken to alter material requirements.

Required delivery dates are established by the time necessary to fabricate the assembly or installation involved so that it will be available on the date scheduled by Manufacturing Planning for its final assembly. The manufacturing schedule is based upon the required completion date of the experimental article and cannot be met unless each assembly and installation is available for incorporation into the final assembly on or before the scheduled dates. For this reason Engineering must provide the fullest cooperation by rapidly selecting substitute materials whenever the original material cannot be obtained in time to meet manufacturing schedule requirements.

Using the AEMO Form

The AEMO shown in Fig. 13:1 is prepared in quadruplicate on 8½- by 11-in. bond and tissue sets. Each set is provided with a serial number for identification purposes. A separate AEMO is issued for each installation and assembly comprising the article, and the number and title of the relevant drawing is given when known, together with the following information specified on the form:

Item. Used in identifying individual items of an AEMO specifying more than one material.

Required. The quantity required of each item to construct all the subject installations or assemblies for one complete article is shown in the "Per Unit" column.

Material required for test and other miscellaneous uses should be listed in the "Special" column.

Size, Description, and Specification. These entries are made in the manner used for drawing bills of material and described in Chap. 8.

Catalogue Reference, Vendor, etc. Enter here catalogue numbers, names of vendors known to have the required material on hand, and similar information of assistance to Material Control and Purchasing.

AEMO Nº 0001

Item	Required: Per Unit	Required: Special	Size	Description	Specification	Catalog Reference, Vendor, etc.	Part No.	Requisition Number / P.O. Number	Required Delivery Date
1	8	8	9-3/4 x 3-9/16	072 CM Steel Sheet	AN-QQ-S-685 COND-A	—	70-31017		
2	8	8	14-3/16 x 2-1/8	7/16 Douglas Fir	AN-F-7	—	70-31016		
3	8	8	9-3/16 x 2-1/8	1/16 Phenolic Sheet	Navy-17P5 Type-FBG Form S, Color-Nat	—	70-31016		
4	4	4	198-1/4 x 1-1/4	2-1/8 Douglas Fir	AN-F-7	—	70-31123		
5	8	8	S228-11-125		Company Standard	Washer	70-31017		
6	40	40	S270 P36-0128		" " " "	Spacer	70-31016		
7	40	40	AN3-23A		Standard Part	Bolt	70-31031		
8	40	40	AN365-1032		" " "	Nut	70-31031		
9	40	40	AN960-10L		" " "	Washer	70-31031		
10									
11									
12									
13									
14									
15									
16									
17									

ADVANCE ENGINEERING MATERIAL ORDER

Prepared by: G H Braverman	Date: 9-9-43	Remarks:	Sheet 1 of 1
Checked by: H Adams	Date: 9-9-43		Issued: 9-9-43
Approved by: D.H. William	Date: 9-9-43		Revision of AEMO: —
			Project: 70
			Model: X4-R
Dwg. No.: 70-31031	Group: Fuselage	Installation or Assembly Title: LONGERON & Fitting Assem Fuselage Monocoque	Effective on: 707 thru 710
			AEMO Nº 0001

Form 566-W

COPY 1—RETAINED BY ORIGINATOR

FIG. 13:1.—Advance engineering material order.

Part No. Company drawing number of part to be made from the listed material.

Requisition No., P.O. No., and Required Delivery Date. These columns are used by the material-control group of manufacturing planning.

Prepared by, and Date. Name of person preparing AEMO and date of preparation.

Checked by, and Date. Name of engineering supervisor checking AEMO and date.

Approved by, and Date. Name of project engineer approving AEMO and date.

Dwg. No. Number of installation or assembly drawing for which the AEMO is issued.

Remarks. Alternate materials and sizes, acceptable substitutes, and vendors known to have stock on hand should be noted.

Group. Engineering group preparing installation or assembly drawing for which the AEMO is issued.

Installation or Assembly Title. Title of installation or assembly drawing for which the AEMO is issued.

Sheet . . . of . . . Used to indicate quantity of pages involved in AEMO.

Issued. Issue date of AEMO.

Revision of AEMO. Cross reference to number of original AEMO, when revised AEMO is issued.
Project. Project for which material is required.
Model. Model for which material is required.
Effective on. Serial numbers of articles for which the material is required.
AEMO No. Each AEMO is provided with a consecutive serial number for identification and reference purposes.

All materials and parts, including castings, standard parts, bolts, nuts, rivets, and the like, required for an assembly or installation should be listed on the AEMO.

Revised AEMO's are issued whenever made necessary by design changes or additions or to authorize material substitutions. These should show the date of revision and the number of the original AEMO in the spaces provided. It is the duty of all engineering supervisors to notify the materials engineer immediately of changes in material requirements.

PROCESSES

Process engineering is necessary in all engineering departments concerned with the development of high-quality products. This service includes establishment of standard processes for the fabrication, heat-treatment, chemical treatment, and finishing of materials. Determination of physical properties and chemical compositions of purchased materials and the execution of experimental and research work to determine improved processes make it desirable for the laboratory to be under the direction of the process engineer.

The basis upon which materials, processes, and finished parts are judged and determined by the process engineer is offered through the medium of laboratory investigation, research, and experimentation. Actual trials on a laboratory scale are conducted when necessary so that all process and finish specifications are thoroughly proved before being placed in effect.

The laboratory equipment and facilities are also employed to discover improved manufacturing methods and investigate new processes offered or suggested by outside sources. In general, the process engineer enables the company to employ efficiently the best equipment, materials, and methods in order to manufacture products of superior economy, quality, and performance.

Finish Specification

The process engineer prepares a finish specification for each new model during its development engineering stage. This specification details the

protective and decorative coatings to be applied to the article, usually on the basis of the nature and location of the material rather than according to part number, and eliminates the necessity of placing detailed

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BT-13, BT-13A, BT-13B, BT-15
and SNV-1 Finish Spec

4. INORGANIC SURFACE TREATMENTS (Cont'd)

4.22 Chromic Acid Dip (Cont'd)

4.222 *not* require inorganic surfaco treatment, unless paint or primer is subsequently applied.

4.3 Protective Treatments for Magnesium Base Alloys

4.31 All magnesium and magnesium-base alloys shall be treated in accordance with spec USA-98-20010. All possible cutting, drilling or forming should be completed before applying such treatments. The maximum protection for magnesium alloys is of greater importance than for aluminum alloys.

4.32 Chrome Pickle Treatment

4.321 This treatment may be used for all magnesium alloy castings and wrought forms covered by Air Forces specifications, with the following exceptions.

4.322 When parts do not allow for dimensional loss.

4.3221 During the full time chrome pickle treatment, there is a maximum surface loss of .0006 inch.

4.3222 A short time treatment, with a loss of .0002 inch per surface, is permitted on completely machined surfaces that are unpainted and serve as bearing areas or fits.

4.323 Assemblies such as castings, containing inserts of brass, bronze or steel.

4.33 Dichromate Treatment

4.331 The dichromate process is recommended in preference to the chrome pickle treatment for parts that will *not* permit the dimensional change that occurs during the chrome pickle treatment.

4.332 The dichromate process may be used to treat castings or parts that contain brass, bronze or steel inserts.

4.333 The following magnesium materials are *not* suitable to receive the dichromate treatment: - Tubing, spec AF-11333; Magnesium Sheets, spec AF-11339. Such materials may be treated by the chrome pickle process.

4.4 Parkerizing

4.41 When parkerizing is desired, the finish shall conform to spec USA-57-0-2. This treatment is suitable for steel armament parts requiring a non-glaring flat black surface that is also wear and rust-resistant.

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FIG. 13:2(*a*).—Finish specification, prepared by process engineer to provide detail finish instructions for a given model.

finish instructions upon the drawings. This practice avoids subsequent checking of each drawing for detail finish information and eliminates issuance of conflicting or confusing finish instructions.

Each finish specification is assigned an identifying number, and a listing of these is made available to all designers and draftsmen. Drawings

show the correct finish specification number for the related model, with this number appearing in the "finish" space of the title block. The checking group makes certain that the drawing refers to the proper finish

VULTEE AIRCRAFT, INC
BT-13, BT-13A, BT-13B, BT-15
and SNV-1 Finish Spec

5. ORGANIC SURFACE COATINGS

5.1 Shop-Primer Coat

One coat of zinc chromate primer, spec AN-TT-P-656, shall be applied to the following, as soon as practicable after the operations of cleaning, sandblasting, dichromating, chromic acid dip, etc:

5.11 All magnesium alloy surfaces.

5.12 All bare aluminum alloy surfaces.

5.13 The "interior" surface *only* of alclad sheet used to fabricate skin, fairing and like parts having one surface exposed (in whole or part) to the airstream.

5.2 Dope-Proofing

Parts or assemblies finished with two (2) coats of zinc chromate primer, shall need no further protection from contact with doped fabrics.

5.3 Joints and Seams

The overlapping portion of all-metal joints and seams will have a minimum of one (1) coat of zinc chromate primer between them, in accordance with the procedure established in para 5.1, except in the case of spot-welded seams.

5.31 Seams - Fuel Tight

The joints and seams of the integral fuel tanks shall be sealed with suitable gasoline-resistant sealing compounds. The compounds used must be insoluble in high-octane aviation fuel, and not subject to shrinking, swelling or cold flow.

5.4 Dissimilar Metals - Insulation of

Where the use of dissimilar metals has not been avoided, each contacting surface shall receive at least one (1) coat of zinc chromate primer, except that cadmium or zinc plated surfaces need not be coated with primer..

5.5 Tubular Parts - Interior Finish

5.5 Open End Steel Parts

The interior of such parts shall receive one (1) coat of zinc chromate primer. The coating may be applied by filling or spraying.

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FIG. 13:2(*b*).—Finish specification, prepared by process engineer to provide detail finish instructions for a given model.

specification. The manufacturing-planning department enters the proper finish specification on all shop orders, and all factory supervisors are furnished copies of the finish specifications. It is their responsibility to place the proper protective or decorative coating on all parts and assemblies.

SPECIFICATIONS ENGINEER

The position of specifications engineer is one requiring a combination of the talents of an engineer, journalist, and artist. This work involves

VULTEE AIRCRAFT, INC
74-8 MFGR'S SPEC

E-4A ENGINE

E-4A(1) THIS AIRPLANE SHALL BE EQUIPPED WITH ONE PRATT & WHITNEY MODEL R-985-AN1 AIR-COOLED, SINGLE-ROW RADIAL ENGINE

E-4A(2) BREATHER GASES SHALL BE PIPED OUTSIDE THE COWLING, PREFERABLY TO A POINT VISIBLE TO THE PILOT DURING FLIGHT.

E-4B LUBRICATION SYSTEM

E-4B(1) THE LUBRICATING SYSTEM SHALL CONSIST OF AN OIL TANK, OIL COOLER WITH THERMOSTATIC RELIEF VALVE, AND SUITABLE CONNECTING LINES.

E-4B(2) THE OIL TANK SHALL BE OF WELDED ALUMINUM-ALLOY SHEET, CAPACITY APPROXIMATELY 10.9 U S GALLONS, WITH ADDITIONAL FOAMING SPACE EQUAL TO APPROXIMATELY 1.09 U S GALLONS.

E-4B(3) EASY ACCESS TO THE TANK FILLER SHALL BE PROVIDED.

E-4B(4) THE OIL SHALL BE COOLED BY A SEVEN INCH (7 IN.) DIAMETER TYPE B-4 OIL COOLER. THE FLOW OF AIR THROUGH THE CORE WILL BE CONTROLLED BY A MANUALLY-OPERATED SHUTTER PLACED IN THE AIR SCOOP. THE COOLING AIR WILL EXHAUST INTO THE ENGINE ACCESSORY COMPARTMENT, AND THEN INTO THE AIR STREAM THROUGH LOUVERS IN THE ENGINE ACCESSORY COWLING

E-4C COOLING SYSTEM

THE ENGINE INSTALLED IN THIS AIRPLANE WILL BE AIR-COOLED, AND EQUIPPED WITH AN N A C A TYPE COWLING TO PROVIDE COOLING AIR FLOW AND MINIMUM DRAG.

E-4D FUEL SYSTEM

E-4D(1) THE FUEL SUPPLY OF THIS AIRPLANE SHALL CONSIST OF TWO (2) INTEGRAL TANKS HAVING A TOTAL CAPACITY OF APPROXIMATELY ONE HUNDRED TWENTY (120) U S GALLONS.

E-4D(2) ONE FUEL TANK OF APPROXIMATELY SIXTY (60) U S GALLONS SHALL BE AN INTEGRAL PART OF EACH SIDE OF THE CENTER SECTION WING PANEL. EACH TANK SHALL COMPRISE A COMPARTMENT FORMED BY THE FRONT AND REAR WING BEAMS, UPPER AND LOWER SKIN COVER-SHEETS, AND CHORDWISE BULKHEADS FORMING THE TANK COMPARTMENT ENDS. ALL SEAMS WILL BE CAULKED WITH A SUITABLE FUEL-RESISTANT COMPOUND. BAFFLE PARTITIONS WILL BE FORMED BY THE WING RIB-SECTIONS CONNECTING BETWEEN FRONT AND REAR BEAMS. IN THE DESIGN OF THE INTEGRAL FUEL TANKS, SEAMS AND JOINTS WILL BE IN THE FORM OF FAYING OR OVERLAPPING SURFACES, IN ORDER THAT THE FUEL-RESISTANT SEALING COMPOUND WILL SERVE ONLY AS A SEALING OR CAULKING AGENT BETWEEN ADJACENT SURFACES.

VULTEE SPEC NO. 574-3

REVISED: 2/16/42

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FIG. 13:3(*a*).—Detail specification for basic-trainer airplane.

preparation of all specifications pertaining to company products, including proposal specifications, sales specifications, construction specifications, design-information reports, and a mass of minor work relating to presentation of accurate engineering information in a manner that will be both interesting and valuable to purchasers of company products.

The work of the specifications engineer begins before the first line of a new design is placed upon a drawing. A design-information report giving the broad features and aims of the proposed design is prepared as a guide for development engineering. As soon as the new design

VULTEE AIRCRAFT, INC
74-B MFGR'S SPEC

E-4D(3) A STANDPIPE SHALL BE PROVIDED AT THE OUTLET CONNECTION OF THE RIGHT TANK TO TRAP A RESERVE FUEL SUPPLY OF APPROXIMATELY SEVENTEEN (17) U S GALLONS WHICH MAY BE DRAWN UPON BY SETTING THE FUEL COCK TO THE "RESERVE" POSITION.

E-4D(4) THERE SHALL BE ONE FUEL COCK PROVIDED, CONTROLLABLE FROM BOTH COCKPITS, TO PERMIT FUEL TO BE DRAWN SELECTIVELY FROM EITHER TANK

E-4D(5) THE FUEL UNIT SHALL CONTAIN A STRAINER, WATER TRAP, WATER DRAIN COCK, AND AN EMERGENCY FUEL PUMP WHICH WILL BE OPERABLE FROM EITHER COCKPIT FOR STARTING, OR FOR SUPPLYING FUEL TO THE ENGINE IN EMERGENCIES. THE FUEL UNIT WILL ALSO CONTAIN A PRESSURE RELIEF-VALVE TO REGULATE THE PRESSURE DELIVERED BY THE EMERGENCY FUEL PUMP.

E-4D(6) FUEL LINES SHALL CONSIST OF FIVE-EIGHTS INCH (5/8 IN.) DIAMETER ALUMINUM-ALLOY TUBING, WITH HOSE CONNECTIONS OR OTHER SUITABLE FITTINGS AT THE ENDS

E-4D(7) A PRIMING PUMP, OPERABLE FROM THE FRONT COCKPIT, SHALL BE PROVIDED FOR PUMPING FUEL INTO ENGINE CYLINDERS FOR STARTING PURPOSES

E-4D(8) EACH FUEL TANK SHALL BE PROVIDED WITH A POTASSIUM DICHROMATE CAPSULE, IN ACCORDANCE WITH AIR CORPS DWG NO. 37B4095-1

E-4E ENGINE CONTROLS

E-4E(1) BOTH COCKPITS SHALL BE PROVIDED WITH CONTROLS FOR THE THROTTLE, MIXTURE, AND PROPELLER. CONTROLS FOR CARBURETOR AIR HEAT AND OIL COOLER AIR-SCOOP SHUTTER WILL BE IN THE FRONT COCKPIT ONLY

E-4E(2) THROTTLE, MIXTURE, AND PROPELLER CONTROLS SHALL BE PROVIDED IN THE FORM OF ONE (1) TYPE B-24 ENGINE CONTROL UNIT IN FRONT COCKPIT AND B-21 IN REAR COCKPIT, MOUNTED TO SHEET STEEL BRACKETS SECURED TO THE LEFT SIDE FUSELAGE STRUCTURE. THE MOVEMENTS OF THE CONTROL HANDLES SHALL CONFORM TO THE REQUIREMENTS OF THE 8TH EDITION OF THE HANDBOOK OF INSTRUCTIONS FOR AIRPLANE DESIGNERS

E-4E(3) THE CARBURETOR HEAT CONTROL LEVER SHALL BE MOUNTED IN THE FRONT COCKPIT ON A QUADRANT PLACED BELOW THE ENGINE CONTROL UNIT; ITS MOVEMENT SHALL BE FORWARD TO DECREASE THE TEMPERATURE OF THE AIR DELIVERED TO THE CARBURETOR.

E-4E(4) THE OIL COOLER AIR-SCOOP SHUTTER CONTROL LEVER SHALL BE PLACED ON THE SAME QUADRANT AS THE CARBURETOR HEAT CONTROL UNITS; ITS MOVEMENT SHALL BE FORWARD TO DECREASE THE TEMPERATURE OF THE OIL.

E-4E(5) ALL ENGINE CONTROLS SHALL COMPRISE INDIVIDUAL SYSTEMS OF PUSH-PULL RODS AND BELLCRANKS.

VULTEE SPEC NO. 574-31

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FIG. 13:3(*b*).—Detail specification for basic-trainer airplane.

assumes definite form, a preliminary specification is prepared to serve as a basis for mutual consideration of the design by all concerned. When all details of the design have been agreed upon and developed, a detail specification is prepared to serve as the basis for final discussions and contract between manufacturer and purchaser.

Detail Specification

An acceptable detail specification should define the basic dimensions, guaranteed performance, and (where applicable) the maximum allowable weight of the article. The general nature of the design should be revealed, and where the customer has established specific construction requirements, these should be presented in detail. Lists of equipment to be incorporated in the design should follow the descriptive text. Illustrations should be used to delineate important features of the design.

Particular care must be used to avoid ambiguous statements. Detail specifications normally become a portion of the contract document and are thereby a possible subject for litigation. Each sentence and paragraph must be written in a clear, concise manner, possible of only one interpretation.

Commitments of the company should always be as broad as possible to provide reasonable latitude for changes found necessary or desirable during development of the detail design. Obligations of the customer, on the other hand, should be specific. This insures that changes desired by the customer, no matter how small, can become subjects for negotiation of cost and schedule alterations.

It is almost certain that some changes will be negotiated during the life of a contract. Whenever these accumulate to a point where the specification no longer reflects the true nature of the article, it will be necessary to revise the specification to incorporate all outstanding changes. Revised pages must then be issued to all persons possessing copies of the specification. See Chap. 14 for detail procedure for specification and report revision.

Construction Specification

As the construction of the first article of the new design progresses, a construction specification describing and illustrating all details of construction is often prepared. This serves as a permanent history of the constructional features of the design for use by the engineering department in future developments and for benefit of the customer when manufacturing rights are involved. Throughout the development of the design, until the last production drawing is completed, the specifications engineer must keep the design-information report on each model up to date, in order that everyone concerned may be constantly informed of all

design requirements. The specification engineer also maintains photographic albums for all models, assists in the preparation of sales brochures, and prepares comparison charts and specialized reports to meet customer inquiries and needs. From this it is easy to see that the position of specifications engineer can become a full-time occupation even in a small engineering department.

All engineering reports, irrespective of their origin, should be routed to the specifications engineer for editing. Only in this manner can all documents issuing from the engineering department maintain a consistent, uniform style. A majority of engineers are poor journalists indeed, and subjecting all engineering reports to a final editing by the specifications engineer will insure uniform outline, pagination and paragraphing, proper grammar, and correct composition.

SERVICE ENGINEERING

Under the broad classification of service engineering can be grouped handbooks, service bulletins, and customer service, in addition to service engineering relating primarily to new product design. The service engineer investigates the serviceability of all product designs, determines a satisfactory solution for all service problems reported by customers, prepares handbooks of instructions relating to company products, and maintains liaison between company and customer on service matters.

All new designs are investigated for serviceability, particular attention being given to ease of disassembly, repair and reassembly, and access to items requiring adjustment, inspection, or lubrication. This study is made concurrent with development of the new product and insures that the customer will receive an article excelling in ease and economy of maintenance and repair. Some engineering departments establish the service engineer as a station of the drawing release system in order to insure that all layout, installation, and assembly drawings will be checked for serviceability prior to release for design or manufacturing. Designs that are questionable from a service viewpoint can be detected before detail drawings are prepared or parts manufactured.

Service Bulletins

All problems involving the maintenance and repair of company products in service are handled by the service engineer, working in close cooperation with the project engineer and company service representatives

to obtain a completely satisfactory solution to all service problems in the shortest possible time. Unsatisfactory service conditions found to be the result of inherent design defects require a satisfactory remedy and

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SERVICE Vultee BULLETIN

SERVICE BULLETIN
VULTEE AIRCRAFT INC VULTEE FIELD CALIF U S A
SERVICE & SPECIFICATION JAMES E. THOMPSON
ENGINEERING SECTION SERVICE & SPECIFICATION ENGINEER

SUBJECT INSTALLATION OF CURTISS AUXILIARY FUEL TANK
REFERENCE: ---
EFFECTIVE ON P-66 Airplanes as Noted

NOTICE This document contains information affecting the National Defense of the United States within the meaning of the Espionage Act (U.S.C. 50:31.32) The transmission of this document or the revelation of its contents in any manner to any unauthorized person is prohibited.

INSTALLATION OF CURTISS AUXILIARY FUEL TANK

P-66 AIRPLANES

REASON FOR CHANGE

1. To provide additional gasoline supply, and permit carrying either a 100 or 300 pound bomb.

AIRPLANES AFFECTED

2. Change to be accomplished on all airplanes. Airplane AF42-6890 had this change completed at the factory.

3. All future production airplanes will have this change accomplished prior to delivery.

SPARE PARTS AFFECTED

4. No spares are affected by this change.

ACCOMPLISHMENT

5. Change to be accomplished by the Customer with all parts being furnished by the Contractor.

DESCRIPTION OF CHANGE

6. This change consists essentially of installing an auxiliary fuel tank to the under surface of the wing center section, on the airplane centerline. To provide clearance for this tank it is necessary to move the loop antenna forward approximately two feet from its present position. To provide clearance for the installation of a bomb rack to support the tank, it is necessary to make cutouts at the forward end of the "belly" fairing and the aft end of the landing-gear center fairing. The auxiliary tank fuel cock is located in approximately the position of the present fuel cock. To permit installation of the fuel lines it is necessary to make cutouts in the front beam, wheel-well nose rib and landing gear

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CHECKED BY C. T. Mulchay Jr. APPROVED BY [signature] CHIEF OF STRUCTURES
APPROVED BY James E. Thompson SERVICE & SPECIFICATION ENGINEER APPROVED BY [signature] PROJECT ENGINEER

FIG. 13:4(a).—Service bulletin for addition of extra-range fuel tanks to fighter airplane.

the issuance of a service bulletin to provide detailed instructions for a rework to eliminate the difficulty. These service bulletins (see Fig. 13:4) are prepared by the service engineer, after proving the correctness of the rework procedure by an actual trial rework in the experimental factory.

All unsatisfactory reports and their remedies are carefully analyzed by the service engineer, and the resultant information compiled for reference during future design of similar products. When this data is

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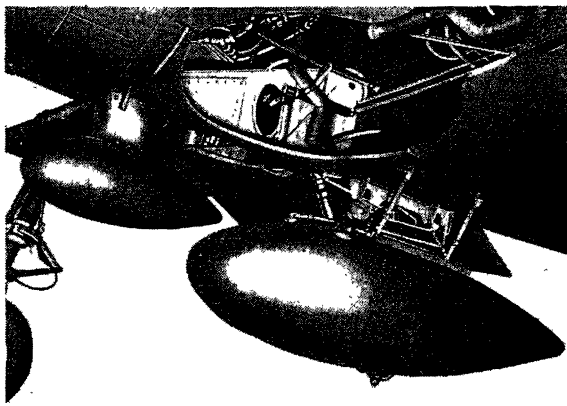

Auxiliary Fuel Tank Installed on P-66 - Left Side

center fairing. A small opening cut in the left side floor provides access for the new fuel cock control rod. The tank and bomb release quadrant is attached to the fuselage tube structure at the right side of the cockpit.

7. *Preparing the Airplane for Rework* - Remove the radio compass loop antenna in accordance with T.O. 01-50FA-2 Sect 5, Para 19. Then remove the 61-06046 wheel-well nose rib and the 61-06191 landing-gear center fairing in the following manner:

a. Remove the rivets attaching the rib to the front beam stiffener.

b. Remove the rivets attaching the outboard ends of the fairing to the front beam.

c. Remove all screws, nuts and bolts attaching rib and fairing, *but do not remove the rivets attaching the rib to the fairing.*

8. Make a cutout at the forward end of the 61-06191 landing gear fairing in accordance with fig. 2. The cutout on the bottom, forward

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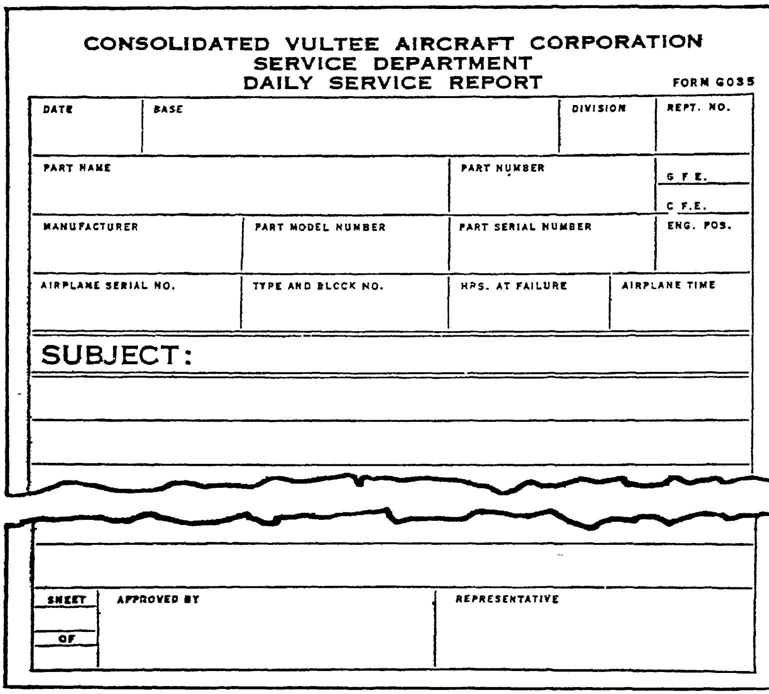
FIG. 13:4(*b*).—Service bulletin for addition of extra-range fuel tanks to fighter airplane.

properly applied during development of a new model, it is possible to eliminate a majority of service difficulties at their inception on the drafting board and avoid repetition of service problems encountered with previous models.

Handbooks

The service engineer should prepare all handbooks of instruction relating to company products. A very high standard of accuracy must be maintained in this work, for it should be fully realized that customer satisfaction is greatly dependent upon accurate, practical operational,


CONSOLIDATED VULTEE AIRCRAFT CORPORATION
SERVICE DEPARTMENT
DAILY SERVICE REPORT
FORM G035

DATE | BASE | DIVISION | REPT. NO.

PART NAME | PART NUMBER | G F E. | C F.E.

MANUFACTURER | PART MODEL NUMBER | PART SERIAL NUMBER | ENG. POS.

AIRPLANE SERIAL NO. | TYPE AND BLOCK NO. | HRS. AT FAILURE | AIRPLANE TIME

SUBJECT:

SHEET | OF | APPROVED BY | REPRESENTATIVE

FIG. 13:5.—Customer service report on unsatisfactory conditions.

maintenance and repair instructions. All handbooks should be carefully checked prior to their release by both engineering and factory personnel in order to insure that the information is not only technically correct but also practical of accomplishment by the average user or maintenance mechanic.

Customer Service

Customer service involves liaison between the company and users of its products to lend all possible assistance in obtaining the maximum serviceability from company products and insure the highest possible degree of customer satisfaction. This function is assigned to the engi-

neering department in some companies; others include the work as a duty of the sales department. When assigned to Engineering, it should be placed under direction of the service engineer.

SURVEY NO. DATE

UNSATISFACTORY REPORT SURVEY

—NOTICE—
IT IS IMPERATIVE THAT ANY ENGINEERING ORDERS RELEASING A CHANGE IN PARTS OR REWORK INSTRUCTIONS AS A RESULT OF THIS SURVEY MUST REFERENCE SURVEY No ________

UNSATISFACTORY REPORT NO	AIRPLANE SERIAL NO.	DATE	CONTRACT NUMBER	MODEL

REFERENCE	DATE

PART NAME	PART NUMBER

DESCRIPTION OF SUGGESTED CHANGES AND/OR COMMENT

ED 69 —OVER— SECTION

SURVEY NO.

Fig. 13:6(*a*).—Unsatisfactory report survey used by customer-service section to request engineering action.

Company service representatives are trained to assist the customer in operation, maintenance, and repair of company products. In some cases these service representatives may be permanently stationed in areas where large quantities of company products are in use, and in other cases they may travel a certain route, making weekly or monthly visits

to users of company equipment and in addition being on call to provide the customer with immediate assistance in the event of service difficulties. In any case the service representatives must furnish the customer-

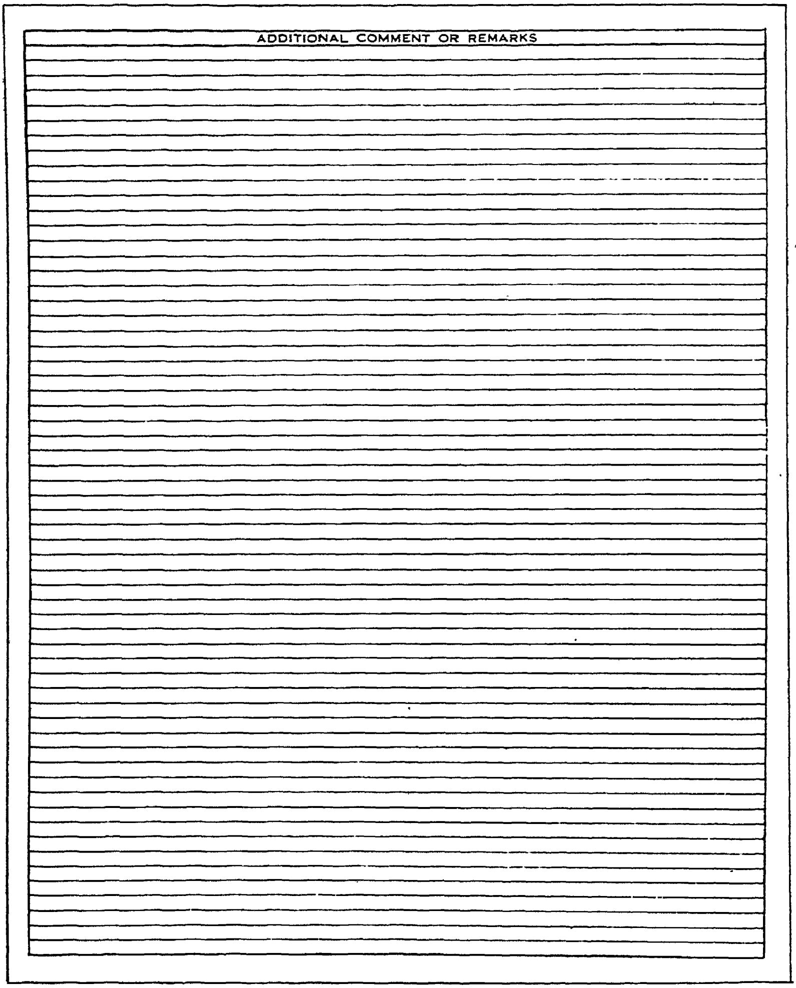

ADDITIONAL COMMENT OR REMARKS

FIG. 13:6(5).—Unsatisfactory report survey used by customer-service section to request engineering action.

service section of the company with an immediate report on all unsatisfactory conditions encountered by customers. The form shown in Fig. 13:5 can be used by service representatives to report unsatisfactory conditions.

All unsatisfactory reports received by Customer Service are analyzed to determine the necessity of requesting engineering action. This decision is governed by analysis of the nature of the complaint. If the trouble appears due to improper operation by the customer, no action is required other than recording the report and "educating" the customer. If the complaint is one that has been previously reported and appears chronic or is obviously due to a design deficiency, a report of the situation (see Fig. 13:6) requesting an immediate remedy for the trouble is forwarded to the project engineer. In many cases Customer Service will recommend the remedy that should be applied. The project engineer takes necessary action to eliminate the difficulty in future production articles and to determine the desirability of issuing a service bulletin to rework existing equipment. Rework of existing equipment always involves determination of whether the company or the customer shall bear the cost of the modification, and this requires coordination with the sales department.

ILLUSTRATION

Two classes of illustration are frequently required: production illustration and technical illustration. The former involves preparation of perspective and isometric drawings of parts to illustrate the proper methods for their manufacture and assembly (see Fig. 13:7). Technical illustrations are similar drawings for handbooks of instruction, parts catalogues, and specifications (see Fig. 13:8). The former is primarily a service to the manufacturing departments; the latter is a technical service directly relating to engineering. Many companies have both classes of illustration assigned to engineering in order to avoid duplication of personnel and equipment.

Operation of Illustration Group

Irrespective of the organization of the illustration group, this activity must be operated on the same basis as other engineering groups. Some engineering executives have made the mistake of operating illustration groups on the premise that the "artistic temperament" of its personnel required special concessions, with resultant deterioration of efficiency and high illustration costs. This premise is entirely erroneous, and Illustration should be operated on the same basis as other engineering groups, with its work estimated and scheduled by Engineering Planning in the usual manner.

The illustration group is strictly a service activity, preparing for other groups and departments the illustrations required for their work. In no

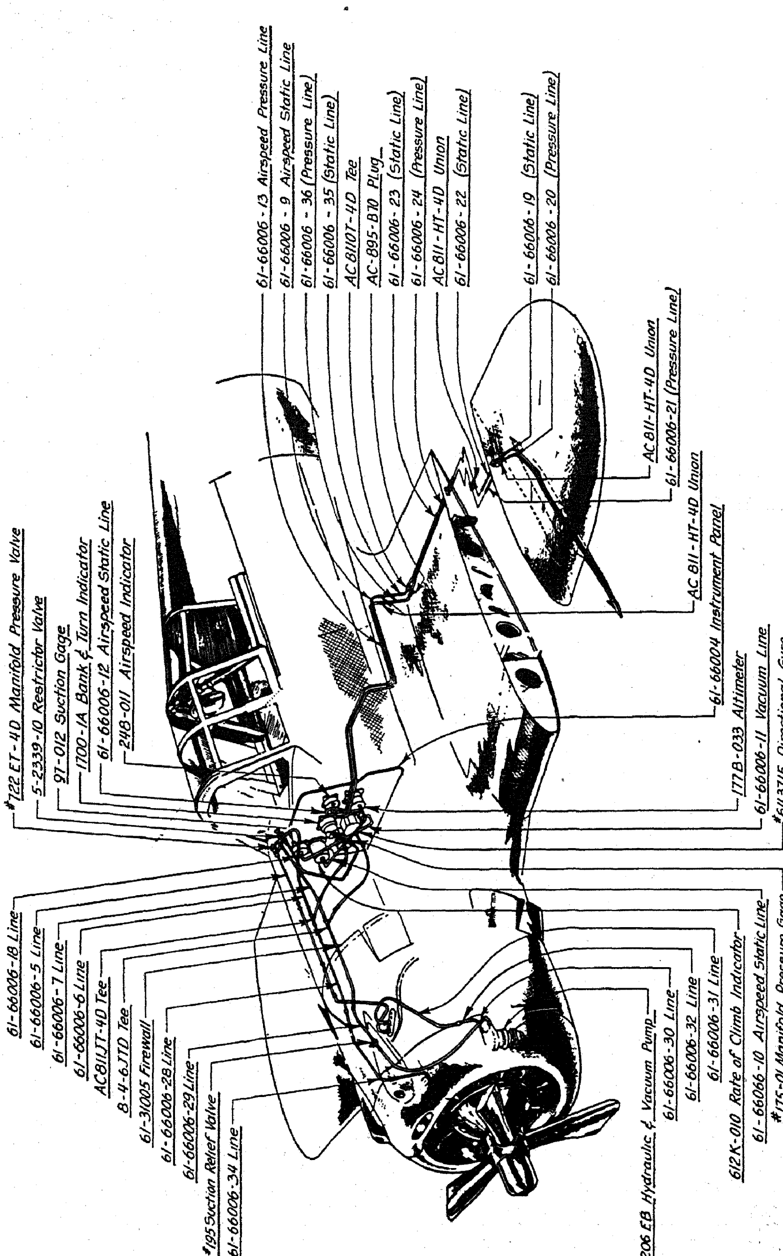


FIG. 13:7.—Production illustration showing installation of airplane-vacuum and air-speed lines.

case should the illustration group be permitted to dictate the nature of an illustration required for a particular purpose, although the illustration group leader should be consulted when there is doubt regarding the

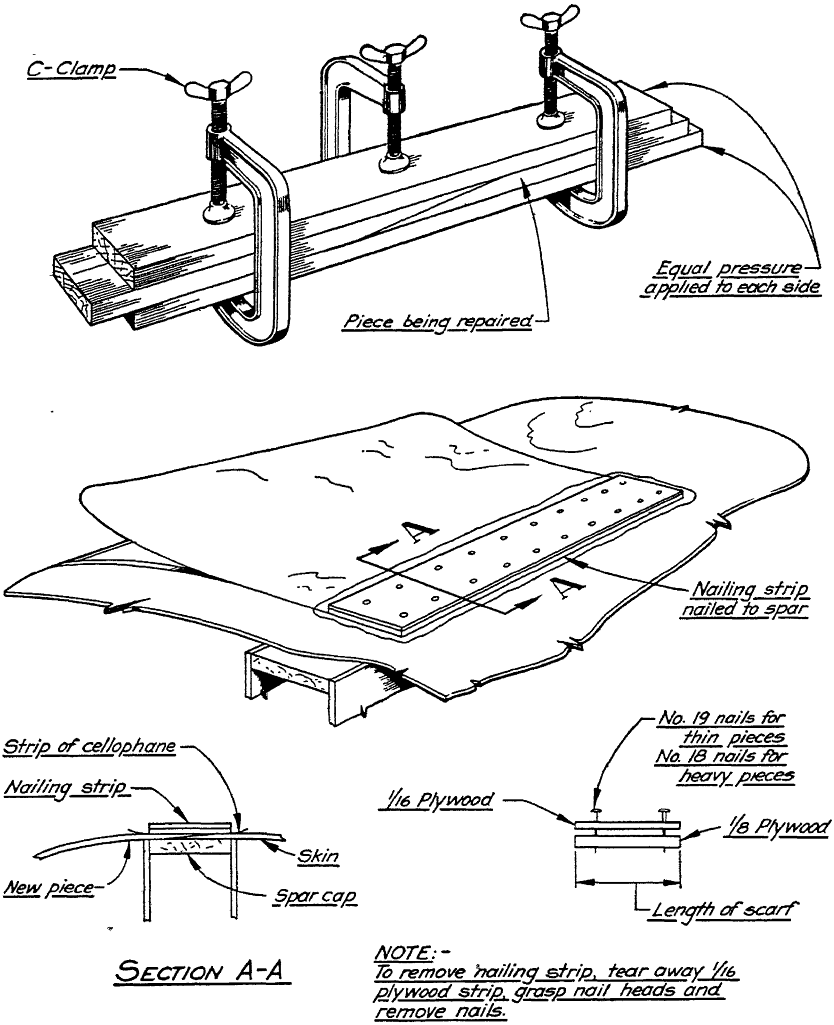


FIG. 13:8.—Handbook illustration showing proper methods of applying glue pressure when repairing wood members.

most effective method of illustrating a particular part or operation. An illustration order similar to that shown in Fig. 13:9 is useful, both as a formal means of ordering illustrations and for a record of the time expended on each illustration.

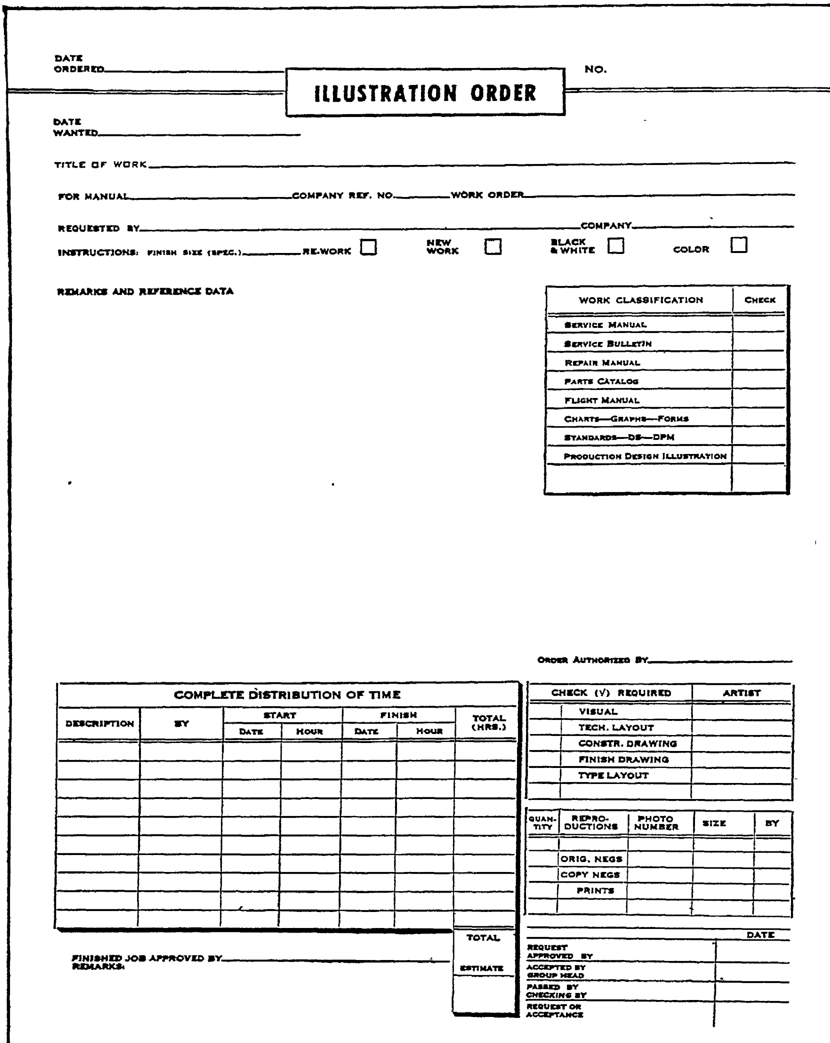


ILLUSTRATION ORDER

DATE ORDERED ______ NO. ______

DATE WANTED ______

TITLE OF WORK ______

FOR MANUAL ______ COMPANY REF. NO. ______ WORK ORDER ______

REQUESTED BY ______ COMPANY ______

INSTRUCTIONS: FINISH SIZE (SPEC.) ______ RE-WORK ☐ NEW WORK ☐ BLACK & WHITE ☐ COLOR ☐

REMARKS AND REFERENCE DATA

WORK CLASSIFICATION	CHECK
SERVICE MANUAL	
SERVICE BULLETIN	
REPAIR MANUAL	
PARTS CATALOG	
FLIGHT MANUAL	
CHARTS—GRAPHS—FORMS	
STANDARDS—DS—DPM	
PRODUCTION DESIGN ILLUSTRATION	

ORDER AUTHORIZED BY ______

COMPLETE DISTRIBUTION OF TIME

DESCRIPTION	BY	START DATE	START HOUR	FINISH DATE	FINISH HOUR	TOTAL (HRS.)
						TOTAL
						ESTIMATE

FINISHED JOB APPROVED BY ______
REMARKS:

	CHECK (√) REQUIRED	ARTIST
	VISUAL	
	TECH. LAYOUT	
	CONSTR. DRAWING	
	FINISH DRAWING	
	TYPE LAYOUT	

QUANTITY	REPRODUCTIONS	PHOTO NUMBER	SIZE	BY
	ORIG. NEGS			
	COPY NEGS			
	PRINTS			

	DATE
REQUEST APPROVED BY	
ACCEPTED BY GROUP HEAD	
PASSED BY CHECKING BY	
REQUEST OR ACCEPTANCE	

FIG. 13:9(*a*).—Illustration order used to requisition illustrations.

REFERENCE PRINTS	RETD.	VENDOR	PHOTO NOS.	RETD.	VENDOR

FIG. 13:9(*b*).—Illustration order used to requisition illustrations.

Illustration Drawing Revisions

The title block shown in Fig. 13:10 is for use with production and technical illustrations. It is intended to be placed *outside* the drawing border and does not necessarily become a part of illustration reproductions. A majority of illustrations are perspective or isometric drawings showing the parts depicted by a certain manufacturing drawing. In this case the illustration is given a drawing number identical with that

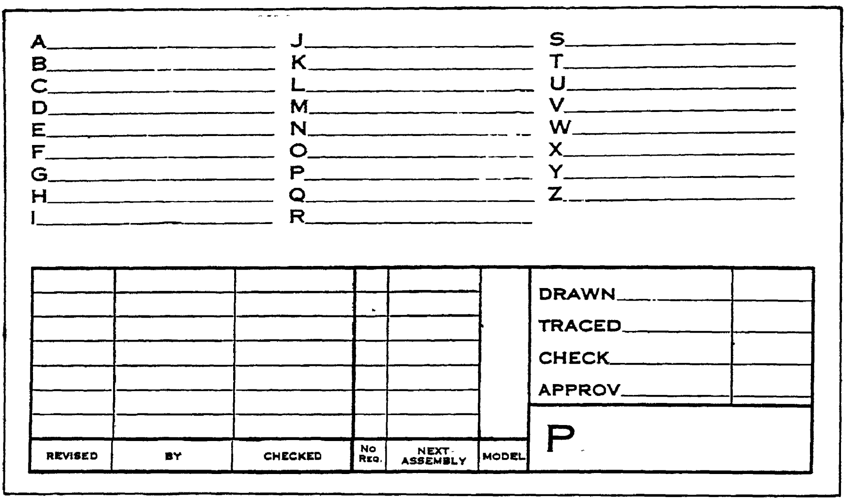


FIG. 13:10.—Title block suitable for production and technical illustrations.

of the manufacturing drawing but with a letter *P* prefix. Other illustrations show parts appearing in several manufacturing drawings. These are assigned individual drawing numbers but still bear the *P* prefix.

Changes on manufacturing drawings usually require a similar revision in the related illustration drawings. The change-letter listing to the left of the title block shown in Fig. 13:10 can be used in conjunction with a cross-reference card file to insure that illustration drawings are revised concurrently with changes in manufacturing drawing. The card file contains a record card for each manufacturing drawing, listing the illustration drawings showing all or part of the manufacturing drawing. One print of each changed manufacturing drawing is routed to the illustration group. Each is examined upon receipt, and the card file is consulted to see if illustration drawings exist for the changed manufacturing drawing. Each card listing an affected illustration drawing is flagged with a red signal, and a notation of the manufacturing drawing-change

letter requiring incorporation in the illustration is posted on the back of the card. All illustration drawings are revised periodically and the signals removed from the cards.

The change-letter listing adjacent to the illustration title block is used to record the drawing changes incorporated in the illustration drawing at the time of its preparation and to list the incorporation of subsequent manufacturing drawing changes. When a drawing change does not require revision of the corresponding illustration drawing, this can be disposed of by simply removing the illustration drawing from the file and entering "Not Affected" in the appropriate change-letter line, with name of the person making the entry and the date.

SPECIALIZED TECHNICAL SERVICES

The technical services discussed in the preceding paragraphs are those applicable and necessary in practically every engineering department engaged in product design. Some engineering departments, engaged in design of highly complex products, will require additional specialized technical services. Among these are stress analysis, weight control, aerodynamics, thermodynamics, and electronics. Engineering groups to carry on specialized technical research and design checking can be established as needed to suit the requirements of each engineering department.

CHAPTER 14

GENERAL SERVICES

It is necessary to provide a variety of general services to implement operation of the engineering department fully. Many of these are clerical in nature, whereas others like photography and parts listing are semitechnical. These are classified as general services, however, as they are often a part of some other department and are not mandatory sections of the engineering organization. Photography is often a responsibility of the sales or public-relations department, while parts listing can be a function of the manufacturing-planning, contract, or sales department or can be subcontracted to a company specializing in the preparation of catalogues. However, these services should be available to the engineering department. Other general services, such as stenographic and library functions, are an integral part of the engineering department.

The basic general services involved in operation of an engineering department are

Parts catalogues	Blueprinting	Supplies
Master-parts lists	Drawing and print files	Stenographic
Spare-parts lists	Drawing release	Correspondence files
Photographic	Library	
Timekeeping	Report release	

Parts catalogue, spare-parts list, photographic, and timekeeping services can be supplied by other departments, but the remainder are basic general services for an engineering organization. Since timekeeping, blueprinting, drawing and print files, and drawing release are considered in other chapters, they are excluded from the detailed discussion of general services.

PARTS CATALOGUES

Parts catalogues provide the customer with information required to order replacement parts for maintenance and repair purposes. It is highly desirable that illustrated parts catalogues be provided in order to insure rapid identification of the correct part. Catalogues for simple articles may require only a single perspective illustration to identify all parts clearly, but an illustrated parts catalogue for a complicated vehicle may involve several hundred illustrations.

There are a variety of possible arrangements for an illustrated parts catalogue, including the elaborate form specified for military aircraft in Army-Navy Aeronautical Specification AN—C—85. A comparatively simple arrangement of an index drawing followed by classified detail illustrations and listings of major installations and assemblies will provide a satisfactory parts catalogue for commercial purposes. The illustrations and listings in Figs. 14:1 through 14:6 show how all stockable, replaceable parts and assemblies comprising an airplane can be shown in a parts catalogue.

Typical Illustrated Parts Catalogue

The catalogue is divided into seven basic sections: wing, empennage, body, landing gear, flight controls, power plant, and equipment, and by

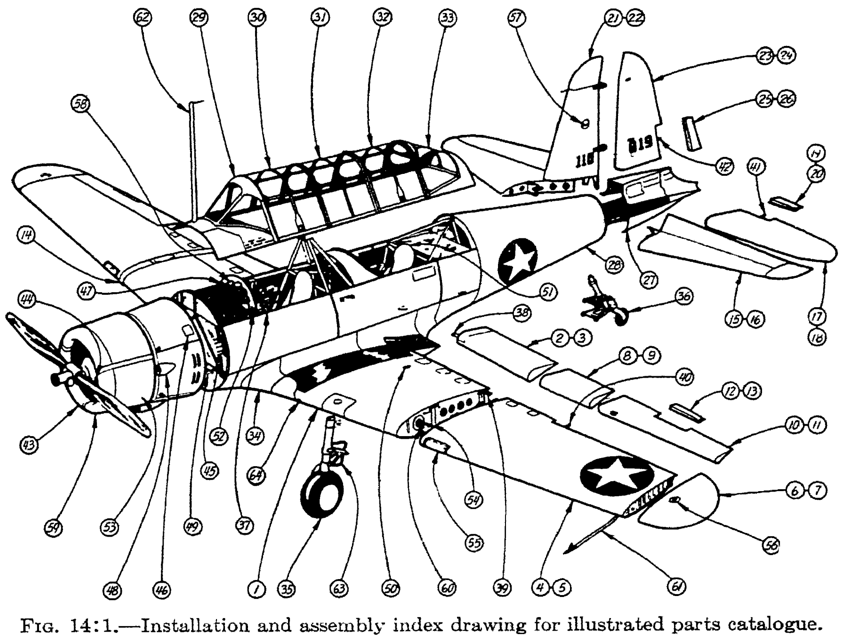


Fig. 14:1.—Installation and assembly index drawing for illustrated parts catalogue.

a simple process of elimination the required part can be located and identified. All the main installations and assemblies comprising the airplane are shown on the index drawing (see Fig. 14:1), with item numbers assigned to each. On the page facing the index drawing is shown a listing (see Fig. 14:2) of these item numbers together with the relevant drawing number, name, and reference illustration figure number.

Ref. No.	Part Number	Title	Fig. No.
		WING	
1	63-06002-502	Panel Assem - Wing Center............	2
2	74-17002	Flap Assem - Center Section Covered LH (Metal)..................	21
3	63-17006	Flap Assem - Center Section Covered LH (Wood)..................	23
4	63-08002-500	Panel Assem - Wing Outer LH (Metal).....................	24
5	63-08026	Panel Assem - Wing Outer LH (Wood) ...	33
6	62-08016	Tip Assem - Wing Outer Panel (Metal)...	34
7	63-08025	Tip Assem - Wing Outer Panel (Wood)........................	35
8	63-17003	Flap Assem - Outer Panel Covered LH (Metal)...........	36
9	63-17004	Flap Assem - Outer Panel Covered LH (Wood)..................	38
10	63-13002	Aileron Assem - Covered LH (Metal)....	40
11	74-13002	Aileron Assem - Covered LH (Wood).....	42
12	63-12012	Tab Assem - Aileron LH (Metal)........	43
13	63-12016	Tab Assem - Aileron LH (Wood).........	44
14	63-01101	Instal - Wing Junction Cover Strip....	45
		EMPENNAGE	
15	63-22002	Stabilizer Assem - Horizontal LH (Metal)..........................	46
16	63-22200	Stabilizer Assem - Horizontal LH (Wood)...........................	49
17	63-25002	Elevator Assem - Covered LH (Metal)...	52
18	63-25015	Elevator Assem - Covered LH (Wood)....	54
19	63-24007	Tab Assem - Elevator LH (Metal).......	55
20	63-24010	Tab Assem - Elevator LH (Wood)........	56
21	63-26002	Stabilizer Assem - Vertical (Metal)...	57
22	63-26015	Stabilizer Assem - Vertical (Wood)....	59
23	63-29002	Rudder Assem - Covered (Metal)........	61
24	63-29015	Rudder Assem - Covered (Wood).........	63
25	63-28005	Tab Assem - Rudder (Metal)............	64
26	63-28C08	Tab Assem - Rudder (Wood).............	65
27	63-31401	Instal - Tail Cone..............	66

Ref. No	Part Number	Title	Fig. No.
		BODY	
28	74-31002-500	Fuselage Assem.........................	68
29	63-32002	Windshield Assem - Pilot's............	86
30	63-32003	Enclosure Assem - Front Sliding.......	87
31	63-32004	Enclosure Assem - Fixed Cockpit.......	88
32	63-32005	Enclosure Assem - Rear Sliding Cockpit.............	89
33	63-32010	Enclosure Assem - Rear Fixed Cockpit.............................	90
34	74-31601	Instal - Wing to Fuselage Fairing.....	91
		ALIGHTING GEAR	
35	63-39001	Instal - Landing Gear.................	93
36	63-46001	Instal - Tail Wheel...................	100
		FLIGHT CONTROLS	
37	74-75101	Instal - Fuselage Flight Controls.....	105
38	63-72301-500	Instal - Wing Center Flap Controls.............................	107
39	74-75301	Instal - Wing Center Panel Flight Controls......................	109
40	74-75401	Instal - Wing Outer Panel Flight Controls.......................	111
41	63-68101	Instal - Elevator Tab Controls........	113
42	63-70301	Instal - Rudder Tab Controls..........	115
		POWER PLANT	
43	74-56004	Instal - Demountable Power Plant................................	117
44	63-59201	Instal - Engine Section and Accessories Controls.............	137
45	74-59101	Instal - Fuselage Section Engine and Accessories Controls.............	143
46	63-63101	Instal - Engine Section Oil System...............................	149
47	63-63201	Instal - Fuselage Section Oil System......................	153
48	63-64701-500	Instal - Power Plant Section Fuel System..........................	156
49	63-64601	Instal - Fuselage Fuel System.........	160
50	63-64501	Instal - Wing Center Panel Fuel System..........................	162

Ref. No.	Part Number	Title	Fig. No.
		EQUIPMENT	
		Furnishings	
51	63-76001	Instal - Furnishings..................	165
		Electrical	
52	74-78101	Instal - Fuselage Electrical..........	175
53	74-78201	Instal - Power Plant Electrical.......	185
54	74-78301	Instal - Center Section Wing Electrical............................	190
55	63-78401	Instal - Outer Wing Electrical............................	191
56	63-78701	Instal - Wing Outer Panel Tip Electrical Equipment..................	192
57	63-78601	Instal - Vertical Stabilizer Electrical Equipment..................	193
58	74-66101	Instal - Fuselage Instrument..........	194
59	63-66201	Instal - Power Plant Instrument.......	204
60	63-66301	Instal - Center Section Instrument...........................	210
61	63-66401	Instal - Outer Wing Panel Instrument...........................	211
		Communications	
62	63-95001	Instal - Radio Equipment..............	232
		Miscellaneous	
63	63-43001	Instal - Brake Control System.........	237
64	63-77000	Instal - Heating and Ventilating......	238

FIG. 14:2.—Installation and assembly index listing for illustrated parts catalogue.

To locate a part, it is necessary only to know what main installation or assembly it forms a portion of, locate the reference illustration for that unit, and then turn to the illustration. All illustrations are identified by figure numbers, and the reference figure will show the detail parts and assemblies comprising the unit. On the page facing the illustration there is a listing similar to that used with the index drawing, except that "Number Required" for the assembly shown is substituted for "Figure Number."

If the item sought is a portion of a subassembly of the reference figure, it will not be identified in the parts listing, and it is necessary to turn to the figure showing details of that particular assembly. This condition is immediately apparent for item numbers of assemblies carry a dash suffix, with the basic number identifying the figure number showing details of the assembly. For instance, the details of an assembly identified on an illustration as "107—1" will be found in Fig. 107 of the parts catalogue.

Using an Illustrated Catalogue

As an example of using the illustrated catalogue described by Figs. 14:1 through 14:6, assume that the part number of the tail-wheel shock-absorber packing rings must be located. By reference to the index illustration (see Fig. 14:1) it is found that item 36 relates to the entire tail gear of the airplane, and the index listing (Fig. 14:2) refers to Fig. 100 of the catalogue for details of the tail-wheel installation. Upon referring to Fig. 100 (see Fig. 14:3) it will be found that the tail-wheel shock-absorber details are shown elsewhere and that *two* reference numbers are indicated for this part, namely, 101—1 and 102—1.

The presence of *two* reference numbers indicates that two different shock absorbers have been used. These may or may not be interchangeable, but reference to the accompanying parts listing (see Fig. 14:4) will reveal the effective production serial numbers for each, and the corresponding illustration may then be selected. Assuming that airplane number 41—1218 is involved, then 101—1 identifies the proper tail-wheel shock-absorber assembly, which obviously is shown at Fig. 101 of the parts catalogue. Upon turning to Fig. 101 (see Fig. 14:5), it is immediately apparent that the packing rings are item 9, and the parts listing (see Fig. 14:6) identifies these as "Part No. 20333, Ring-chevron Packing, 5 required."

All equipment and furnishings items are shown and listed under "Equipment," not in the structural sections. For instance, details of the landing lamps are shown in the "Electrical" group of the equipment section rather than in the wing section, although a cross reference to the

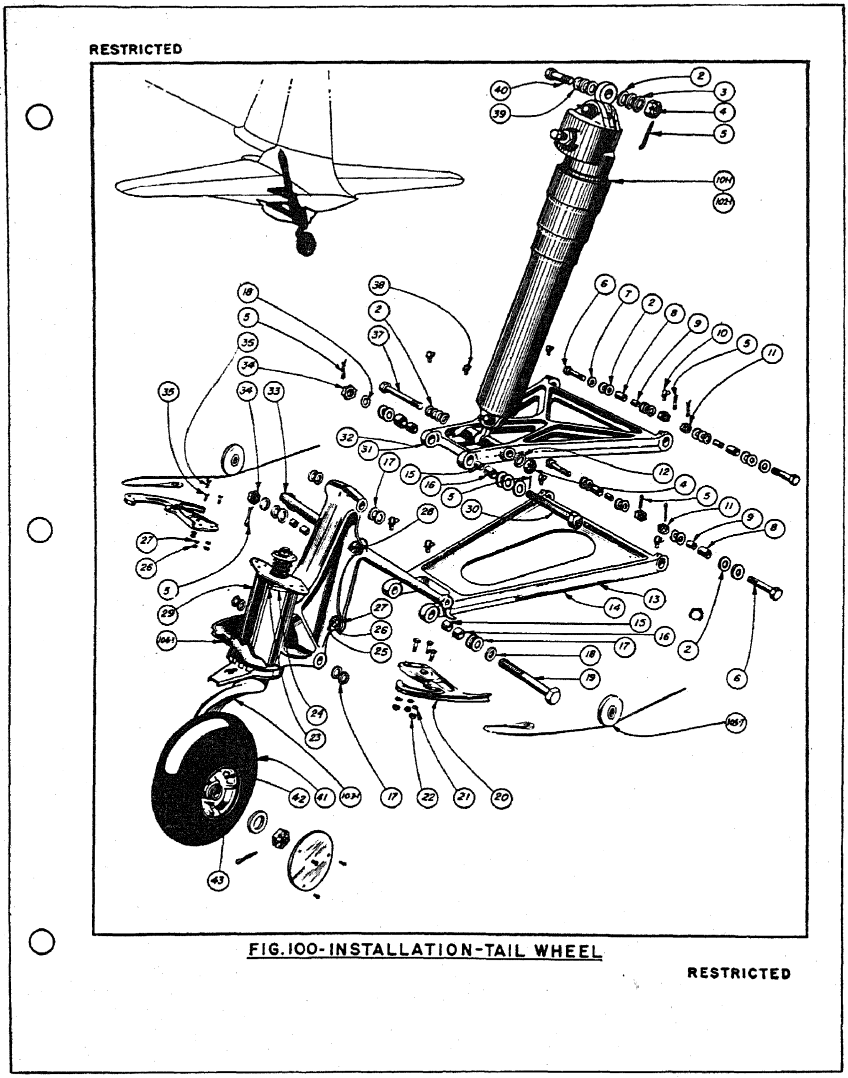


FIG. 14:3.—Installation drawing for illustrated parts catalogue.

"Installation of Outer Wing Panel Electrical Equipment" appears on the relevant wing-structure illustration. This arrangement follows aircraft drafting practice for all parts catalogues must follow the arrangement of corresponding engineering drawings. Unless this is done, the concurrent revision of parts catalogues and engineering drawings becomes extremely difficult.

Ref. No.	Part Number	Title	No. Req.
1	63-46001	Instal - Tail Wheel	1
2	VS80-14-33-.025	Washer	24
3	AN960C-716	Washer	1
4	AN310-7	Nut	2
5	AN380-3-3	Pin - Cotter	8
6	AN6-16	Bolt	4
7	AN960-616	Washer	2
8	63-46103	Bushing - Tail Wheel Post Housing Rocker	4
9	63-46120	Spacer - Tail Wheel Post Rocker Arm Forward	4
10	1637	Lubricator - Alemite	4
11	AN310-6	Nut	4
12	AN960-716	Washer	1
13	63-46003-2	Arm - Rocker	1
14	63-46003	Arm Assem - Tail Wheel Post Housing Lower Rocker (Consists of items 9, 10, 13, 15 and 38)	1
15	63-46121	Spacer - Tail Wheel Post Rocker Arm Aft	4
16	63-46122	Bushing	4
17	VS80-16-41-.025	Washer	8
18	AN960-816	Washer	2
19	AN8-44	Bolt	1
20	63-46009	Quadrant	2
21	AN960-416	Washer	2
22	AN365-428	Nut	2
23	AN502-10-4	Screw	4
24	AN995-C40-7	Wire - Lock	2
25	AN3-6A	Bolt	2
26	AN365-1032	Nut	4
27	AN960-10	Washer	4
28	VS21-10-11	Screw	2
29	63-46115	Housing - Tail Wheel Post	1
30	AN8-37	Bolt	1
31	63-46002-2	Arm - Rocker	1
32	63-46002	Arm Assem - Tail Wheel Post Housing Upper Rocker (Consists of items 8, 10, 16, 31 and 38)	1
33	63-46008	Bracket - Tail Wheel Post Pulley Guide	1
34	AN310-8	Nut	2
35	AN3-6A	Bolt	4
36	AN4-7A	Bolt	2
37	AN7-42	Bolt	1
38	1641	Lubricator - Alemite	4
39	63-46129	Washer - Upper Shock Absorber Fuselage Bracket Locking	1
40	AN7-16	Bolt	1
41	No. No.	Casing - Smooth Contour (spec 26547)	1
42	No. No.	Tube - Smooth Contour (spec 26550)	1
43	No. No.	Wheel Assem (spec 25272)	1
		REFERENCE ASSEMBLIES	
101-1	41060	Strut Assem - Tail Wheel Shock Absorber Used on 41-1211 thru 41-22161	1
101-2	63-46015	Strut Assem - Tail Wheel Used on 41-22162 and up	1
103-1	63-46013	Post Assem - 10.5" Tail Wheel	1
104-1	63-46101	Instal - Tail Wheel Boot	1
105-7	AN210-3A	Pulley	2

FIG. 100 - INSTALLATION - TAIL WHEEL

FIG. 14:4.—Installation parts listing for illustrated parts catalogue.

The basic data used in compiling parts catalogues are obtained either from the drawing bills of material or from master-parts lists when they

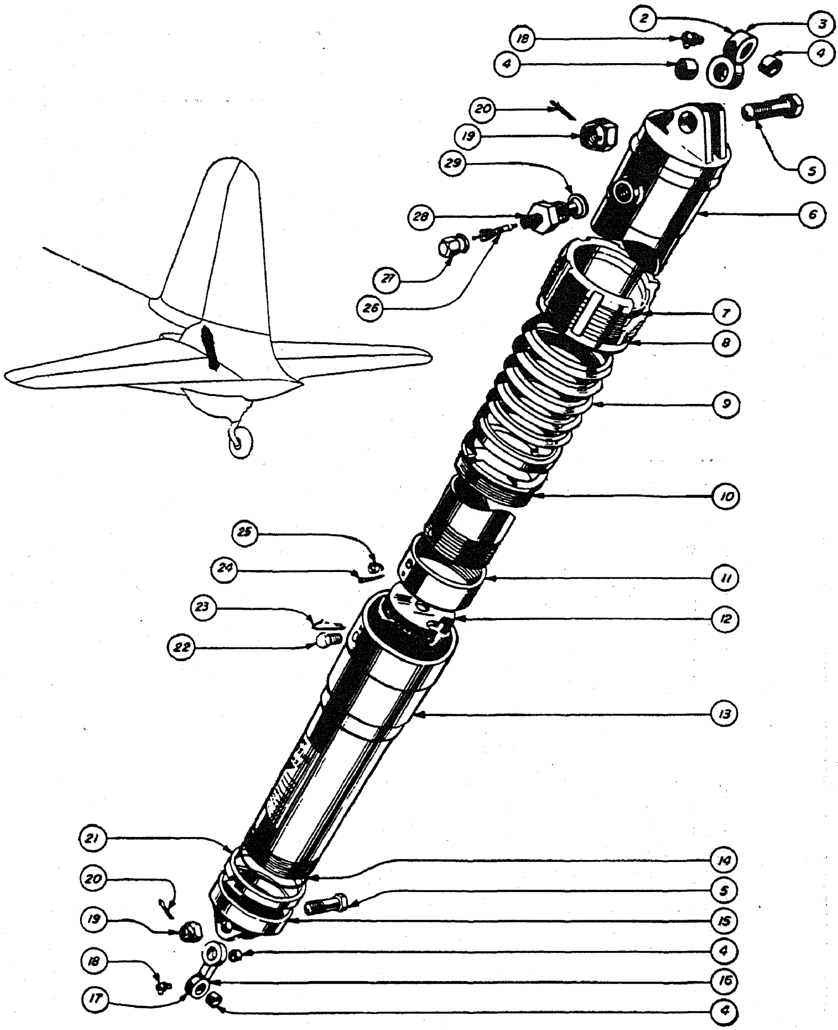


FIG. 14:5.—Assembly drawing for illustrated parts catalogue.

are prepared by the engineering department. Regardless of the source the data should be checked and double-checked before being incorporated into a parts catalogue. Users of the company's products must

Ref. No.	Part Number	Title	No. Req.
1	41060	Strut Assem - Tail Wheel Shock Absorber........................	1
2	11007	Link Assem - Tail Wheel Shock Strut Upper (Consists of items 3, 4, and 18)......................	1
3	11007-1	Link...........................	1
4	11070	Bushing........................	4
5	An7-13	Bolt...........................	2
6	41058	Tube Assem - Tail Wheel Shock Strut Piston..................	1
7	20300	Washer.........................	1
8	21056	Nut - Tail Wheel Shock Strut Packing........................	1
9	20333	Ring - Chevron Packing...........	5
10	11049	Stop - Tail Wheel Shock Strut.....	1
11	21044	Bearing - Tail Wheel Shock Strut Piston.........................	1
12	11048	Orifice - Tail Wheel Shock Strut..	1
13	21055	Tube - Tail Wheel Shock Strut Outer..........................	1
14	20312-050-202	Ring - "O" Type Packing Seal......	1
15	21057	Cap - Tail Wheel Shock Strut......	1
16	11130	Link Assem - Tail Wheel Shock Strut Lower (Consists of items 4, 17 and 18)......................	1
17	11130-1	Link...........................	1
18	1637	Lubricator - Alemite............	2
19	AN310-7	Nut............................	2
20	AN380-3-3	Pin - Cotter...................	2
21	11620	Nut - Tail Wheel Shock Strut Lock..........................	1
22	10304-3-3AH	Bolt...........................	1
23	AF995-C40-6	Wire - Lock....................	1
24	AN380-2-2	Pin - Cotter...................	1
25	11026	Screw - Tail Wheel Shock Strut Piston Lock....................	1
26	AN809-1	Core - High Pressure Air Valve....	1
27	AN813-1	Cap - High Pressure Air Valve.....	1
28	AN812-1	Body - High Pressure Air Valve....	1
29	20300-0160.024-064	Washer.........................	1
		NOTE 41060 is used on 41-1211 thru 41-22161	

FIG. 101 - STRUT ASSEMBLY - TAIL WHEEL SHOCK ABSORBER

FIG. 14:6.—Assembly parts listing for illustrated parts catalogue.

place complete dependence upon the parts catalogue when ordering urgently needed replacement and repair parts. Issuance of an erroneous parts catalogue can severely damage the company's reputation and compromise the best plans for building customer good will.

MASTER-PARTS LISTS

A master-parts list shows all parts required for a particular article or model, in the approximate order of assembly used for its construction, and becomes a guide for all departments concerned with manufacturing the parts detailed on engineering drawings. It should also list the raw-stock material required to manufacture each part. A separate master-parts list (MPL) should be prepared for each assembly drawing, arranged somewhat like the 11- by 17-in. form shown in Fig. 14:7, which provides for

Last Corr. The symbol ϕ is placed in this column opposite each revised item involved in an MPL change.

Item No. Used when necessary for identification of individual items on the MPL.

Zone. Identifies the drawing-zone location of parts.

Part No. Drawing (part) number of item.

Change Letter. Current change letter appearing on drawing.

Requirements, L.H. and R.H. The quantity required of each item to construct both the left- and right-hand opposite versions of the assembly. When assembly is left-hand only, requirements are entered in L.H. column.

Setback, 1, 2, 3, 4. The assembly order is shown by a system of setback or marginal indention. The final assembly appears in column 1; subassemblies and details assembling directly to the final assembly appear in column 2. Parts required for the subassemblies are listed in column 3; parts comprising subsubassemblies appear in column 4.

Part Name. Significant portion of drawing title.

Effective on, from, through. Production serial numbers of articles upon which each part is used.

Material, Size, Description, Spec. Material information is entered in the identical manner described in Chap. 8 for drawing bills of material.

Special Information. Used for entries by other departments receiving copies of the master-parts list or special data relating to use of a part.

The title-block strip at the bottom of the master-parts list provides the following information:

Date Issued. Issue date of new or revised MPL.

Superseded. Issue date appearing on obsolete MPL superseded by revised issue.

MPL Change Letter. Change letter identifying MPL revision. This may differ from assembly drawing-change letter as MPL is frequently revised without affecting drawing.

Parts Lister. Name of person preparing or revising MPL.

Checker. Name of person checking MPL after preparation or revision.

Model, Next Assembly, and Requirements per "Unit" and "Assembly." Model-requirements block is used in same manner as that appearing in assembly drawing title block (see Chap. 8). Lists the model requirements for the assembly drawing described by the MPL.

Effective on, from, and through. Shows effective production serial numbers of the next assemblies listed in the model-requirements space.

Remarks. Used for explanatory notes.

BOOTH MANUFACTURING CORPORATION — BURBANK, CALIFORNIA

MASTER PARTS LIST

# DENOTES SEPARATE PARTS LIST

Last Chng	Item No.	Zone	Part Number	Change Letter	Req'd L.H.	Req'd R.H.	Set Back 1	Set Back 2	Set Back 3	Set Back 4	Part Name	Effective On From	Effective On Through	Size	Material Description	Material Spec.	Special Information
	1		15100	C	1						Cylinder Assembly-Shimmy Damper Reservoir	151-1	& Up	-	--	-	
	2		AN313-1	-	1						Cap - Valve	151-1	151-64	-	Purchased part	-	Used with air-loaded
	3		AN809-1	-	1						Core	151-1	151-64	-	Purchased part	-	reservoir only
	4		AN812-1	-	1						Valve	151-1	151-64	-	Purchased part	-	
	5		AN901-5A	-	1						Gasket - Connection Seal	151-1	151-64	-	Purchased part	-	
	6		AF995-32-4	-	1						Lockwire	151-65	& Up	-	Purchased part	-	
	7		151008	B	1						Plug - Screen	151-65	& Up	7/8	3/4 hex 24ST bar	QQ-A-354,ConT	
	8		151007	A	1						Cover - Screen	151-65	& Up	1/4	3/4x.935 Al tube	WW-T-787	
	9		151009	A	1						Screen	151-65	& Up	7/32x4-3/4	35 mesh brass cloth	Commercial	
	10		AN380-2-2	-	1						Pin - Cotter	151-1	& Up	-	Purchased part	-	
	11		151003	D	1						Plug - End	151-1	& Up	11/16	1-11/16D 24ST rod	QQ-A-354,ConT	
	12		AN6227-23	-	1						Packing	151-1	151-64	-	Purchased part	-	Air-load reser only
	13		151006	B	1						Spring - Reservoir Cyl.	151-65	& Up	45	.120D music wire	AN-W-17	
	14		151002	D	1						Piston	151-1	& Up	1-5/8	1-9/16D 24ST rod	QQ-A-354,ConT	
	15		An6227-23	-	1						Packing			-	Purchased part	-	
	16		151005	D	1						Rod - Indicator			2-9/16	9/16D CM rod	AN-QQ-S-684,ConE	
	17		AN380-2-2	-	1						Pin - Cotter			-	Purchased part	-	
	18		151004	B	1						Plug - End			11/16	1-11/16D 24ST rod	QQ-A-354,ConT	
	19		AN6227-23	-	1						Packing			-	Purchased part		
	20		AN6227-5	-	1						Packing			-	Purchased part	-	
	21		AN900-6	-	1						Gasket - Annular			-	Purchased part	-	
	22		AF905-6	-	1						Plug - Filler			-	Purchased part	-	
	23		151001	Z	1		#				Cylinder Assembly - Reservoir	151-1	& Up	-		-	
	24																
	25																
	26																
	27																
	28																
	29																
	30																
	31																
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	37																
	38																
	39																
	40																
	41																
	42																
	43																
	44																
	45																
	46																
	47																

Date Issued	Parts Lister	Checker	Model	Next Assembly	Req'd per Unit	Req'd per Assem	Effective On From	Effective On Through	Remarks
8/23/45	D. A. Johnson	J.E. Thompson	151	15001	1	1	151-1	& Up	1.-NE8630 tube, Spec AN-T-15 or NE8735 tube, Spec AN-T-22 may be substituted for SAE4130, Spec AN-WW-T-850.
Superseded			152	15002	1	1	152-1	& Up	2.-17ST bar or rod, Spec FED-A-351 may be substituted for 24ST bar or rod, Spec FED-QQ-A-354.
M.P.L. Chg. Ltr.									

Replaces Drawing No.	Drawing Title	Page	Job Number	Chg Letter	Drawing No.
..O.T.	Cylinder Assem - N.L.G. Shimmy Damper Reservoir	1 of 1 pages	151-34	C	15100

FIG. 14:7.—Master parts list for hydraulic shimmy damper subassembly.

Replaces Dwg. No. Filled in with either the word "None" or the assembly drawing number involved.

Drawing Title. Exact title appearing on assembly drawing described by MPL.

Page . . . of . . . Pages. Number of individual page and total quantity of pages comprising the MPL.

Job No. Used by engineering Release when MPL is released concurrently with new or revised drawing.

Change Letter. Current assembly drawing change letter.

Dwg. No. Number of assembly drawing described by MPL.

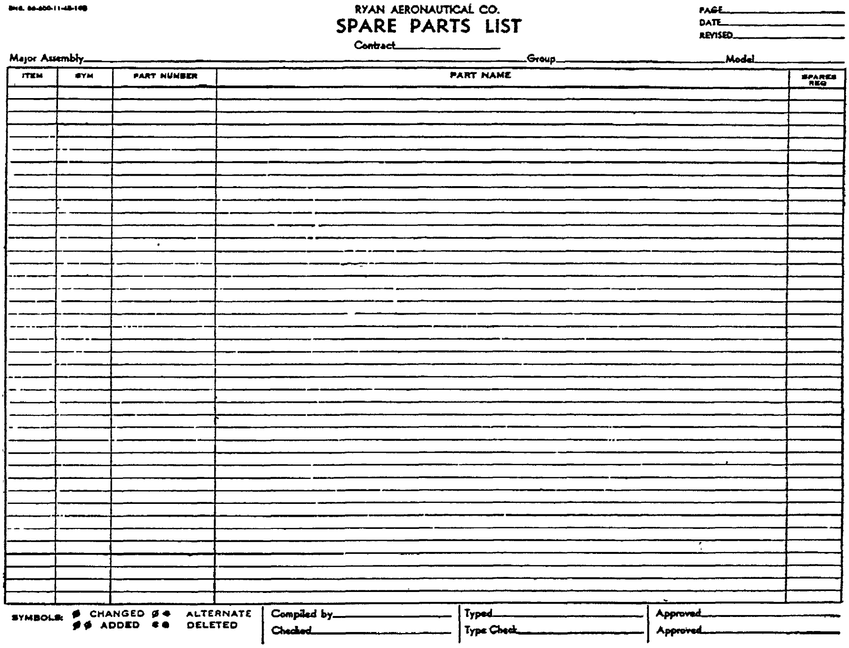
Issuance and maintenance of master-parts lists should be assigned to a capable person provided with ample facilities. A properly prepared, accurate MPL is a valuable asset to every department concerned with the manufacture of parts described by engineering drawings, but incorrect master-parts lists are worse than useless. If the MPL is prepared and issued concurrently with drawing releases, a drawing bill of materials is not needed as it would be a duplication of a considerable portion of the MPL information. Concurrent release can be accomplished by establishing the MPL group as a station in the release system, in accordance with the optional arrangement shown in Fig. 9:2. New and revised MPL's are prepared to accompany each drawing release. The information required for the MPL's is obtained from the drawings and notices of change.

The compilation of the MPL's begins with release of the first drawing for a new model and continues throughout production of the model. Small articles will require few MPL's, one for the final assembly drawing and others for subassembly drawings. Large, complicated articles, such as aircraft, will require many MPL's. In the latter case an MPL index, similar to that shown for a parts catalogue in Fig. 14:2, should be provided. Each MPL should be identified with its proper group for ease in filing in the correct assembly order.

Master-parts lists books, containing one print of the current issue of each MPL, should be provided all manufacturing departments, in addition to those for the purchasing and engineering departments. These should be maintained in an up-to-date condition by the MPL group as experience indicates that individual recipients of a document such as this cannot be depended upon to place new and revised pages properly in their correct locations. The MPL book for each model will begin with the final assembly drawing listing, followed by sections describing each functional grouping. Each section will begin with an MPL for the "top assembly" called out on the final-assembly drawing. This will be followed by MPL's for the assemblies and subassemblies making up the "top assembly," arranged in the approximate order used to assemble the article in the factory.

SPARE-PARTS LIST

Manufacture of the proper quantities of parts for production articles is established by the engineering drawings, bills of material, and/or master-parts lists. It is always necessary to manufacture additional quantities of certain parts as "spares" for replacement and repair purposes. Determination of the kind and quantity of these parts may be a



RYAN AERONAUTICAL CO.

SPARE PARTS LIST

Contract______

PAGE______ DATE______ REVISED______

Major Assembly______ Group______ Model______

ITEM	SYM	PART NUMBER	PART NAME	SPARES REQ

SYMBOLS: ø CHANGED ø• ALTERNATE
øø ADDED •• DELETED

Compiled by______ Checked______ | Typed______ Type Check______ | Approved______ Approved______

FIG. 14:8.—Spare-parts list for authorizing manufacture of spare parts.

responsibility of engineering, or it may be assigned to the contract or sales departments. In each case instructions authorizing their manufacture must be issued.

The form shown in Fig. 14:8 can be used to authorize manufacture of spare parts and provides a listing of part number, part name, and requirements for each item to be manufactured as a spare part. The quantity and kind of spares is usually established as part of contractual requirements in government contracts. In the case of commercial articles it is necessary to base the spares releases upon information compiled from past spare-part sales.

The spare-parts list is prepared and copies issued to the manufacturing-planning department concurrent with release of engineering draw-

ings for a new model. Revisions to the spares list are issued when requirements change owing to alterations in contract requirements or when indicated by changing trends in spare-part orders from customers.

PHOTOGRAPHIC DEPARTMENT

The position of chief photographer for a manufacturing concern is one requiring knowledge of a variety of subjects outside the realm of the

RYAN AERONAUTICAL COMPANY
PHOTOGRAPHIC DEPARTMENT

PRINT ORDER Order No 1075

Date Ordered________ Date Required________

Ordered by________ Department________ Approved by________

NO. OF PRINTS NEGATIVE	NO. OF PRINTS POSITIVE	DELIVER TO	DEPARTMENT	SPECIAL INSTRUCTIONS

FOR PHOTO DEPARTMENT USE ONLY

Date Printed________ By________ Date Delivered________

FORM PH 4 3M SETS 10-43-102

FIG. 14:9.—Order form for photographic prints.

usual commercial photographer since his subjects will require practically every form of still and motion-picture photography. The daily work of the photographic department may include such a variety of "shots" as photographs of visitors, newly employed personnel, and laboratory tests; views for advertising purposes; record photographs; motion pictures of structural members under load for study by the structures engineers; and photographs for specification and handbook purposes of company products and parts under construction.

When the photographic department reaches a size where separate personnel are employed as cameramen and laboratory technicians, it is important for the chief photographer to be an administrator as well as a photographer. Knowledge of company engineering and manufacturing processes become more important than skill with a camera.

The photographic department should be operated as though it were a small business enterprise, divorced from actual contact with a majority of company personnel. All ordering and delivery of work should be

accomplished through written orders approved by the chief photographer. A form suitable for ordering photographic prints is shown in Fig. 14:9. A similar form can be used for ordering photographs and should specify the nature of the photograph desired, location of the subject, and time that photograph can be taken. In this manner an efficient photographic department can be operated and minimum costs maintained.

ENGINEERING LIBRARY

In every engineering department there is need for an engineering library. Small engineering departments may find that a separate filing cabinet, maintained by the engineering file clerk, is adequate for this purpose. Large departments usually have a person specifically assigned to the duties of librarian, with adequate facilities for filing and recording large quantities of books, magazines, technical reports, and other data of value to the designers and draftsmen.

The basic function of the engineering library is systematic filing and indexing of all technical data required for reference by the engineering department. Here should be maintained up-to-date files of reference data, including government and industry design, material and process specifications, vendors catalogues and company specifications and reports, technical magazines, and reference books relating to the work of the engineering department. The responsibility of the librarian involves not only arrangement of the material but also immediate incorporation of all amendments and changes affecting library data to prevent the reference information's becoming obsolete. Material loaned from the library can be recorded on charge-out cards identical with those used for loaned blueprints (see Chap. 10).

Release of Company Reports

Release of all reports, specifications, and similar documents prepared in the engineering department should be accomplished by the librarian. These are usually typed on vellum pages for blueprint or direct-line reproduction. When a report is completed, it is delivered first to the writer's supervisor for checking and approval. The supervisor checks the report, has necessary corrections accomplished, obtains the required approval signatures, determines the quantity of copies required, and forwards the completed report to the librarian with a memorandum listing the required distribution of copies of the report.

The librarian checks the correctness of report number and title with the numbers clerk and obtains the required copies of the report from

Blueprint, ordering necessary photographic prints from the photographic unit and report covers typed with the required data from the stenographic group. The librarian then assembles the required copies of the report and binds the original in a cover suitable for filing. Issue numbers (beginning with "1") are assigned to each copy of the report, and the copies are forwarded to their destinations. Copies sent to destinations outside the engineering department are forwarded through the coordination unit of Engineering Planning. The original and one copy are filed by the librarian.

REPORT ISSUE RECORD

No. 208-18

TITLE Handbook of Instructions For Hydraulic Actuating Cylinders

ISSUE No.	DATE	ISSUED TO	REVISIONS A	B	C	D	E	F	G	H
1	8/28/45	Library	9/12/45							
2	8/28/45	Library	9/12/45							
3	8/28/45	J. E. Thomson	9/12/45							
4	8/28/45	H. H. Miller	9/12/45							
5	8/28/45	J. R. Von-Blank Aeronautical, San Diego 12, Calif.	9/12/45							
6	8/28/45	" " " " . "	9/12/45							
7	9/12/45	R. E. Cooke, Bureau of Aeronautics, Navy Dept., Washington, D.C.	9/12/45							

FIG. 14:10.—Report issue record for recording location of report copies.

REPORT ISSUE RECORD

An issue record, similar to that shown in Fig. 14:10, should be maintained for each company report. This provides for recording the forwarding dates of revised pages, in addition to the original release.

No. Report number.

Title. Complete title of report.

Issue No. Consecutive issue numbers, beginning with "1," are assigned to copies of the report.

Date. Issue date of each copy.

Issued to. Person receiving copy of the report and his department number. Also mailing address if outside company.

Revisions, A, B, C, etc. Each revision is assigned a change letter, beginning with *A* for the first revision. The dates on which copies of revised pages are forwarded to holders of copies of the report are entered under the proper change letter.

Revisions to Company Reports

Revisions to a company report should be identified by a change letter (beginning with *A*) and be accompanied by a revision notice explaining the nature of the revision, similar to the notice of change used for drawing alterations. The original copy of the revised pages is sent to the librarian, together with the revision notice. The librarian obtains sufficient sets of revised pages and revision notices to provide for all copies of the report. One set of revised pages, accompanied by a revision notice, is forwarded to each holder of a copy of the report. It is the responsibility of the holder of the report to insert the revised pages in their proper places and remove and destroy the obsolete pages.

All revised report pages (including new pages added after initial release of the report) should be identified by placing "Revision—(Letter): (Date)," in the lower left corner of each revised page. All revised pages require page numbers, and pages added between existing pages should be identified by letter suffixes. Thus, page 21*a* is placed between pages 21 and 22. The same method can be used to identify added illustrations.

Obsolete Reports

When a report becomes obsolete, the originating engineering supervisor should notify both the librarian and numbers clerk to that effect. The librarian should recall and destroy all copies of the report, except the original and one library copy which is marked "Canceled." The numbers clerk enters the date of and authority for cancellation in the report numbers book.

Standard Arrangement of Reports

Persons receiving copies of company reports are inclined to judge the company by the appearance of these documents, and a definite effort should be made to maintain high standards of quality for all engineering reports. This involves not only correct grammar and composition but usage of neatly printed report covers and title, index, and text pages (see Figs. 14:11 through 14:14). The report cover should be printed on paper that permits typing report number and title directly upon the front cover, enclosed within a box provided for that purpose, as shown in Fig. 14:11. This avoids unsightly gummed labels for application of the report identification.

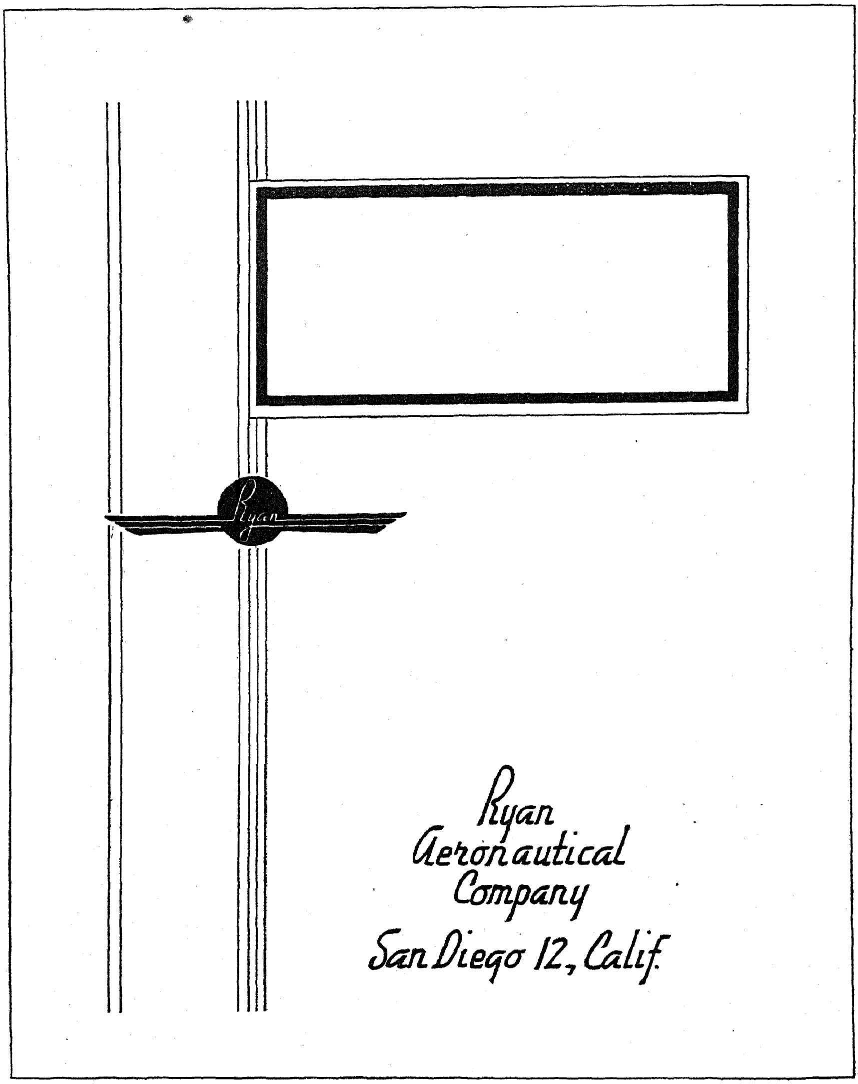


FIG. 14:11.—Front cover for engineering reports.

INTERSTATE AIRCRAFT
&
ENGINEERING CORPORATION
WILSHIRE DIVISION
LOS ANGELES CALIFORNIA

MODEL REPORT DATE

TITLE

SUBMITTED UNDER

Prepared By____________________

Checked By____________________

Approved By____________________

—A—

FORM 308 W

FIG. 14:12.—Title page for engineering reports.

INTERSTATE AIRCRAFT

LIST OF CONTENTS

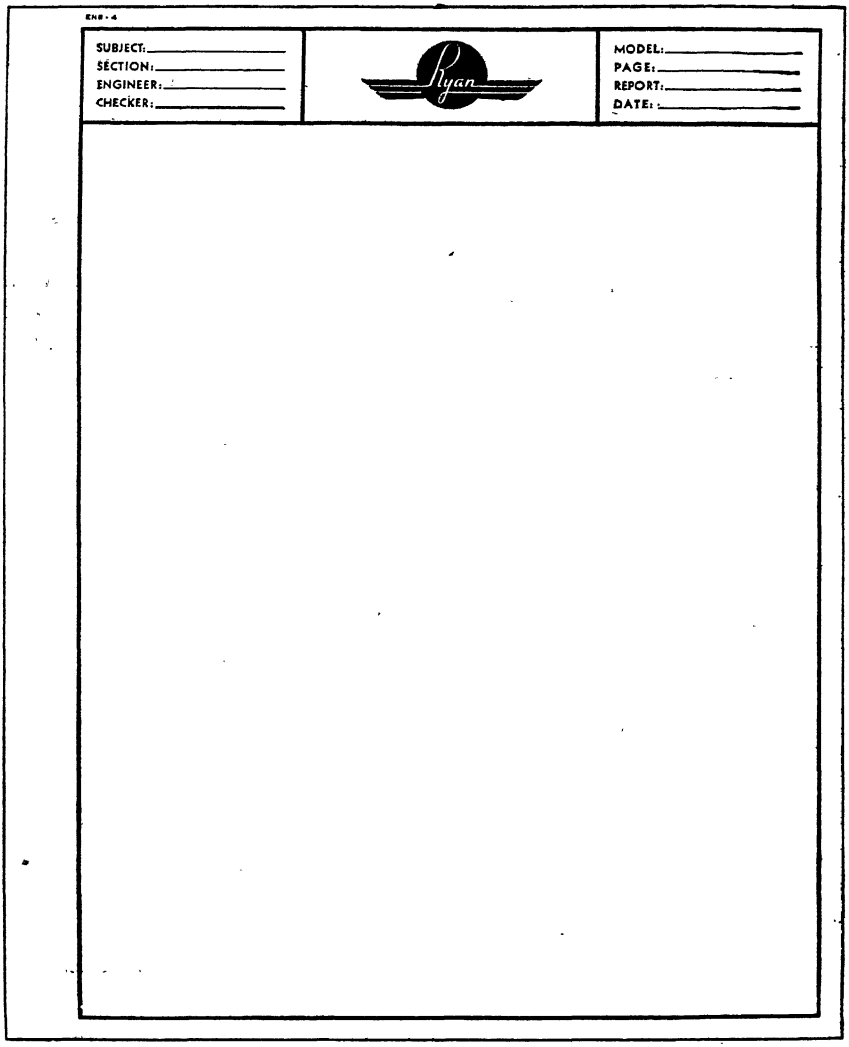
PARAGRAPH	TOPIC	PAGE

REPORT

—1—

FORM 310-W

FIG. 14:13.—List of contents for engineering reports.



ENG-4

SUBJECT:
SECTION:
ENGINEER:
CHECKER:

Ryan

MODEL:
PAGE:
REPORT:
DATE:

FIG. 14:14.—Text page for engineering reports.

STENOGRAPHIC FACILITIES

The nature of the written material produced by the engineering technical and general services necessitates special training for stenographers employed in the engineering department. These not only should be capable typists but should also be familiar with the special terms and symbols used in engineering and the proper arrangement of letters, specifications, and reports that meet the requirements of various agencies to whom these are forwarded.

Letters directed to government activities require a different form from that used for commercial business correspondence, and unless the proper style is employed, there may be delays in obtaining replies—due to the difficulty of routing improperly prepared letters through government channels. Slightly different forms are sometimes used, but in general the arrangement shown in the following example will be suitable for correspondence addressed to any government agency:

THE BLANK AERONAUTICAL CO.

Lindbergh Field, San Diego 12, Calif., USA

2 January 1945

CONFIDENTIAL

Letter No. 73—28—995—137

From: The Blank Aeronautical Co., San Diego 12, Calif.

To: The Chief of the Bureau of Aeronautics
Navy Department
Washington, D. C.

Attention: (When required)

Via: Bureau of Aeronautics Resident Representative
The Blank Aeronautical Co.
San Diego 12, Calif.

Subject: Contract NOa(s)1332: Model SNB—1 Airplanes, Improvement and Changes in.

Reference: *a.* Naval Air Station, Jacksonville, Fla., conf ltr to Blank Aero., NA29/SNB—1/F13 (190321), dated 17 Nov. 1945; Subject, Pilot Tube Installation.
b. If more than one reference involved.

Enclosure: *a.* Blank Aero Engineering Bulletin 45—15*a* (6 copies HW).
b. If more than one enclosure.

1. Paragraphs must be numbered, with the numbers flush with the left-side margin. Subparagraphs should have the first line indented seven spaces and identified by letters beginning with *a*.

2. The introductory heading for the second page should include the security classification, letter number, "to," "attention," and subject, in that order. The page number and date should appear in the upper right corner.

3. Note that neither salutation nor complimentary closing is used.

4. Enclosures should indicate whether forwarded with the letter, using HW as an abbreviation for "herewith," or under separate cover, using the symbol SC.

THE BLANK AERONAUTICAL CO.

____

John J. Jones
Chief Engineer

A quantity of copies are required with letters addressed to government agencies, and the proper amount varies with the agency. This should be determined, and the proper quantity of copies should be dispatched in every case to insure rapid handling by the government agency. Additional copies are prepared as necessary for distribution within the company.

LETTER NUMBERS

All correspondence should bear an identifying letter number in order to facilitate filing and provide a positive means of referring to specific letters. A universally applicable system employs the department number, subject number, writer's pay-roll number, and consecutive serial number of the letter. This is used in the specimen letter on page 290, where letter number 73—28—995—137 indicates that this letter originated in department 73, relates to subject 28, was written by employee 995, and is the 137th letter originating in department 73.

Uniform subject numbers should be established for use by all departments of the company. A number is assigned to each active engineering project, with additional numbers identifying miscellaneous and special subjects. A master listing of letter numbers is maintained by a designated stenographer in each department to insure that the proper serial number will be assigned to each letter.

CORRESPONDENCE FILE

For the engineering department, a central correspondence file should be established where one copy of each outgoing and incoming letter is filed. This file should normally be in the coordination unit of Engineer-

ing Planning so that this activity can serve as a clearinghouse for information released by engineering. At least two types of files should be maintained: one according to letter numbers and the other arranged by subject.

STENOGRAPHIC POOL

When stenographers are employed in the engineering department for general stenographic work rather than assigned to a specific group, control of their work assignments must be provided in order to insure efficiency. These stenographers can be considered as a "stenographic pool" and should be responsible to the chief clerk. All work accomplished by the stenographic pool should be assigned by the chief clerk, and stenographers should not be permitted to accept work from individual engineering employees. Unless this procedure is followed, it is difficult to allocate miscellaneous stenographic work properly so that efficient accomplishment of each assignment is insured on or before the time when it is required.

CHAPTER 15

FUNDAMENTALS OF ENGINEERING MANAGEMENT

The more important aspects of engineering organization and methods have been considered in preceding chapters. The degree to which these are successfully administered governs the efficiency attained by the engineering department and reflects the competency of its management.

Detail methods, which are given for a majority of the operational functions, may not be *directly* applicable to all engineering departments as modification is often required by variations in size, nature, variety, or complexity of engineering activities. However, the detail methods given here represent practical procedure used to handle prime functions and establish basic control in successful contemporary engineering departments. Analysis of similar functions in other engineering departments will reveal the modification necessary to establish efficient control. It should be borne in mind that the principal effort should be directed to *simplifying* the system, "paper work," and handling required to execute the function—without sacrificing control.

The basic organization and operation described in preceding chapters can be applied in all cases, irrespective of the size or nature of the engineering department, despite the fact that a majority of the examples describe methods used by medium to large departments. These methods can readily be reduced to basic fundamentals and applied to even the smallest engineering staff.

CONTROLLED FLOW

Control is the desired end with all engineering methods—control of the flow of work through the department in order to insure that all assignments are completed in minimum time, with maximum accuracy, and with adequate record of accomplishment and handling. It can be said that the basic principle is "controlled flow of material through men and machines," to borrow an expression from Manufacturing Planning. Drawings are the *material* in this case; drafting instruments, reproduction equipment, and other engineering tools become the *machines*. The

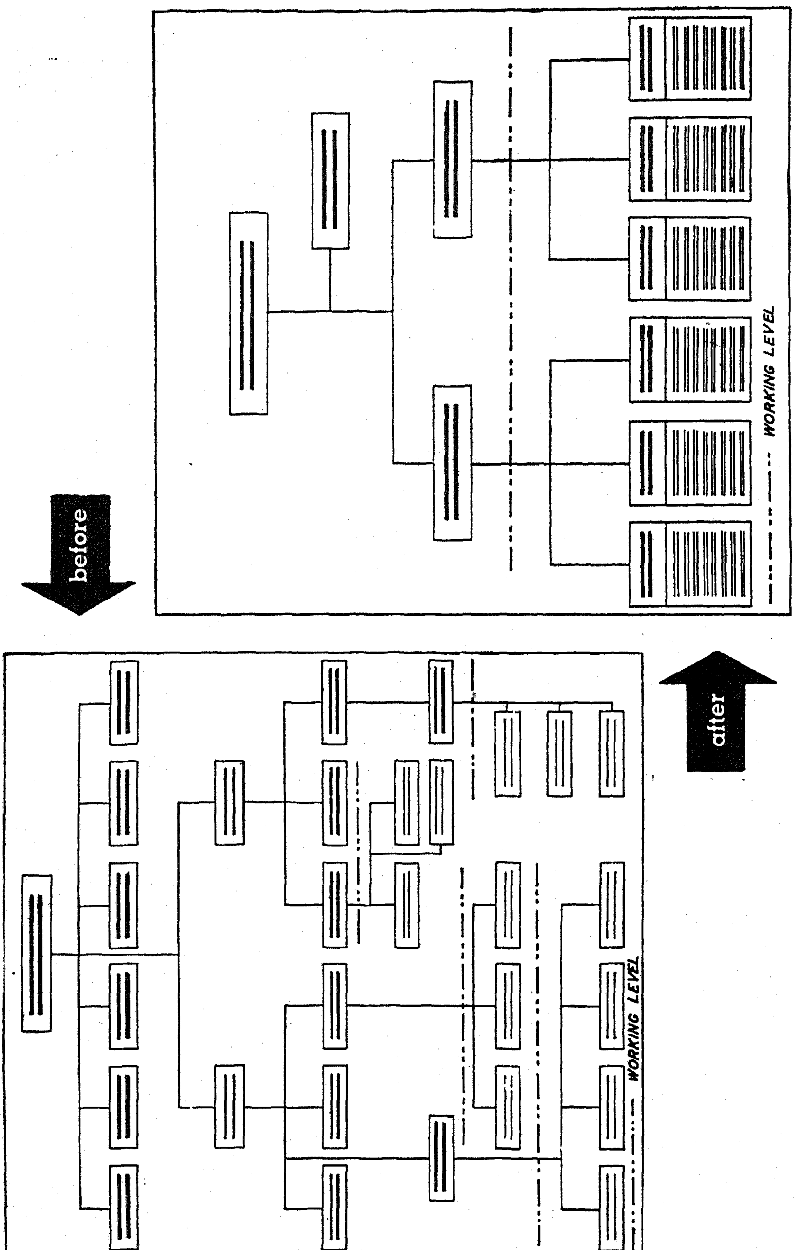


FIG. 15:1.—Simplification of departmental organization through analysis of functions.

principle of "controlled flow" is the basic fundamental of attaining efficient operation in all activities—whether manufacturing, engineering, or clerical. Controlled flow also implies straight-line, uninterrupted flow, with elimination of duplication and unnecessary handling.

Controlled flow applies equally well to organization and the establishment of responsibility and lines of authority. An effective organization must maintain simple, effective control of the department's operation. Duties and responsibilities must be clearly defined; authority must be properly delegated; and divided responsibility or overlapping authority carefully avoided.

In all cases the organization must be simple if it is to be practicable and the *working level* maintained as high as possible. The ideal condition avoids more than *one* level of administrative control between the chief engineer and the supervisors responsible for work accomplishment. It may be difficult consistently to maintain such a high working level in large departments, but it can usually be provided. See Fig. 15:1 for graphic examples.

FUNDAMENTALS OF MANAGEMENT

Efficient engineering management depends upon application of six fundamentals: (1) complete understanding of the goal; (2) a detail plan for reaching the goal; (3) a simple, practicable organization; (4) competent personnel; (5) control of the work flow; and (6) adequate follow-up.

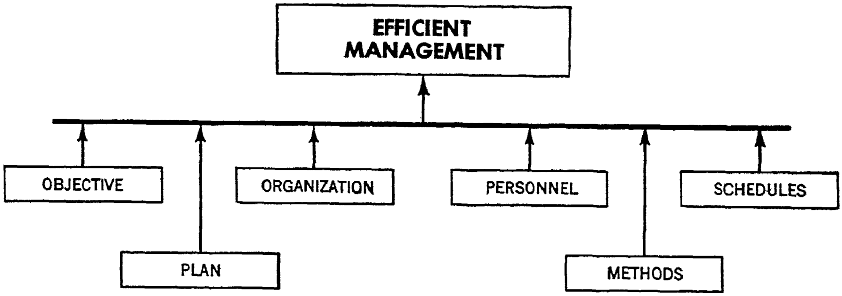


FIG. 15:2.—Fundamentals of management.

When these fundamentals are correctly understood and applied, each person involved with engineering management will have control of his *objective*, *plan*, *organization*, *men*, *methods*, and *schedules*.

The most important fundamental is maintaining a clear-cut understanding of the job to be done—both today and as far into the future as practicable. All administrative and supervisory personnel must con-

stantly have a complete understanding of the over-all, long-range engineering program. Each must understand the exact nature of his responsibility for carrying out the program. The degree of detail comprehension should increase and the scope of responsibility decrease in proportion to the nearness of the working level.

It is always desirable that *everyone* in the engineering department knows the *general* aspects of the engineering program. Departmental morale and efficiency suffer severely whenever personnel are excluded from knowledge of the general nature and purpose of the work in process. Only in rare cases do security considerations make it necessary to restrict such information.

THE PLAN

It is hardly possible to spend too much effort in planning the course to be followed in reaching the objective of an engineering program. This planning must be continuous, for an engineering program does not simply exist for consummation of one project but is constantly in the process of revision, expansion, and contraction as projects are completed and new work is planned.

Once a plan is prepared, its successful fulfillment becomes largely a matter of delegating each piece or parcel of it to competent personnel, followed by proper coordination and control to insure successful accomplishment within allotted times.

Establishment of a detail plan enables accurate cost estimating and successful cost control. The detail plan of each project should be prepared in a form that permits issuing copies to each person concerned with its accomplishment. This information should be revised and reissued whenever a significant change takes place. The project plan can be issued as a "design-information report," establishing the general nature of the project and listing approved work orders, all customer requirements, and governing specifications. Brief factual data should be given in the nature of a design specification for the article covered by the project, including basic dimensional data and minimum performance requirements. If this report is properly prepared and concurrently revised as work progresses, it will represent a complete, accurate design specification upon completion of the project.

Use of a design-information report for each project insures that all personnel will work to identical basic design data and precludes the possibility of time wasted through misunderstanding of the course to be followed during development of the design. It will further insure that only those designs and purchased parts approved by customer and engineering management will be incorporated into the project.

COST CONTROL

Methods of collecting and allocating costs are a basic part of the plan for managing an engineering department since intelligent planning is impossible without accurate knowledge of costs. Cost control should go beyond the strictly timekeeping and accounting phases of collecting and allocating costs. It should also encompass establishment of departmental budgets and cost standards.

The first step is an over-all budget for the engineering department, followed by individual budgets for each operating section. These budgets must have flexibility for possible revision to accommodate changes in the engineering plan. Cost standards should be established for all repetitive work, such as drawing release, blueprinting, and parts listing. In these cases the time expended is directly proportional to either the quantity or area of drawings processed. Budgets can be established and revised on the basis of estimated drawing quantities. Actual efficiency can be measured as the percentage realization of the standards and can be increased by reducing all unnecessary operations.

Budgets for design and drafting work are difficult to reduce to standards. Although drawing quantity and area are still measures of the work accomplished, the effort required will be proportional to the complexity of the design. Only by comparison with the cost of similar engineering work, accomplished under similar conditions, is it possible to arrive at reasonably accurate design and drafting estimates. All estimates and budgets presented to top management should be realistic, containing suitable allowances for all reasonable contingencies. Nothing discredits the engineering department more rapidly than repeated failure either to meet completion dates or to maintain budgets.

Once budgets are established, each section of Engineering must operate within its current allowance and be guided by periodic cost reports. A time-charge system should be established to provide daily cost accumulation by charging each engineering hour against specific, designated account numbers (see Chap. 4 and Appendix I for details).

ORGANIZATION

Departmental organization has been thoroughly considered in Chap. 1 on the basis of the requirements for medium to large engineering groups. In the case of very small departments the organization will be different in appearance but identical in principle.

There will, of course, be no full-time administrative or service functions. Instead, each draftsman and engineer will be assigned a portion

of the service duties found in a large department. These can be discharged without seriously hampering the employee's main assignment of drafting or design since the "nondrafting" demand upon his time will be relatively small. For instance, one draftsman can be assigned part-time duties as file clerk and blueprint operator. Another can devote time to liaison between Engineering and the factory departments. Still another may spend time preparing handbooks, specifications, service

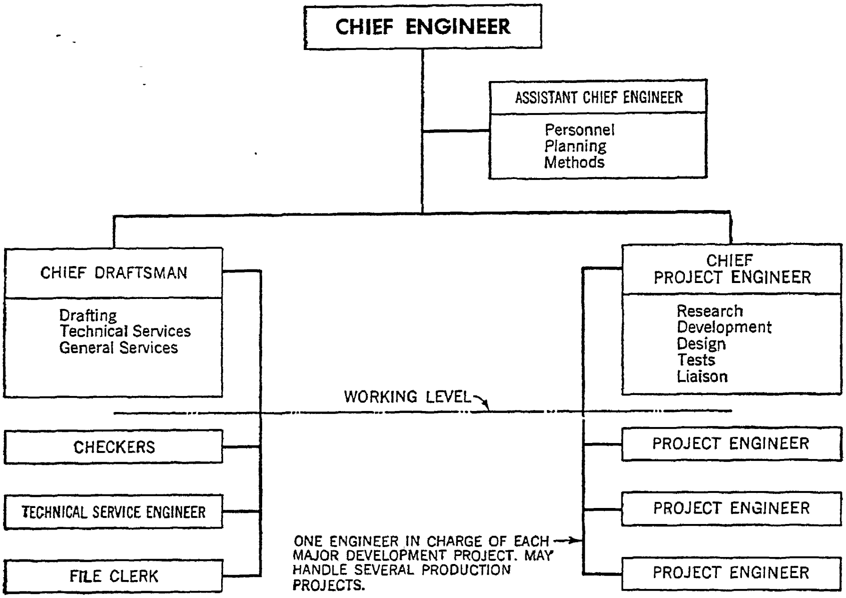


FIG. 15:3.—Functional organization chart for small engineering department.

bulletins, and the like. The net result will be the assignment of all important technical and general service functions as part-time duties of specified personnel—without hampering their prime purposes of design and drafting. Each will report directly to the chief engineer and in a sense will serve as both supervisor and worker.

This arrangement is possible only when the department is very small. As soon as the personnel increases beyond a certain point, the burden of administrative and service functions multiplies to a degree where it must be made the *full-time* responsibility of designated employees. It is difficult to state exactly where this point is reached, but it is reasonable that whenever a department reaches 20 employees, the burden of supervision will interfere with the chief engineer's prime functions of policy making, design direction, and customer liaison. It is then neces-

sary to relieve him of this burden by delegating certain responsibility and authority.

With a department of 20 employees it would be difficult to justify the quantity of executive personnel in even the simple arrangements described in Chap. 1. These organizational structures are predicated upon a department of at least 50 employees. Instead, simple division of supervisory control into two prime phases of drafting and design will suffice. This can be done by establishing the positions of *chief draftsman* and *chief project engineer,* as shown in Fig. 15:3.

It may be desirable to establish also the position of *assistant chief engineer,* particularly for a department of intermediate size (between 20 and 50 employees), for the purpose of handling personnel, planning, and methods as well as providing for a department head during absence of the chief engineer. If this position is not considered desirable, then personnel, planning, and methods may be handled by the chief draftsman.

With further increase in personnel it becomes practicable to subdivide again the supervisory and administrative responsibilities and enlarge into the organizational patterns described in Chap. 1. This does not involve the "overhead" that may appear to develop, for in smaller departments the same service functions exist but on a smaller scale—small enough so that they are part-time functions of drafting personnel, giving the appearance of low overhead owing to the absence of service job titles. As the department increases in size, the service functions simply become more apparent, and the actual percentage increase should not greatly exceed the proportional increase in personnel.

PERSONNEL CONTROL

Every engineering department, irrespective of size, demands personnel control. This requirement becomes more acute as the department increases in size, until a point is reached (approximately 300 employees) where personnel matters require the full-time attention of an engineering personnel manager.

Personnel control can be logically divided into two phases of human relations and procedure. The first phase usually increases in importance more rapidly than the actual numerical increase in personnel; for as the engineering department expands, it becomes increasingly difficult to select personnel both for competency and for harmonious personality.

Certain personnel-control procedure is necessary in every department and invoves simple, practicable methods of handling personnel procurement and termination and maintaining assignment and history rec-

ords, wage and salary reviews, and overtime authorization. In a small organization the recording and preliminary screening involved in personnel procurement can be handled by the company personnel department.

In every case it is desirable to maintain complete employee history records, showing education, experience, and other particulars regarding each engineering employee. When this information is readily available to the chief engineer, considerable time can be saved when planning new job assignments, promotions, and wage adjustments.

A definite policy of wage and salary reviews should be established since a practice of hit-or-miss increases cannot be tolerated. At specified periods all employees should be reviewed on the basis of job performance to ascertain if an increase in wage or salary is merited. All job-performance reviews should be made by the employee's supervisor, subject to the approval of the chief engineer.

Overtime is an evil that should be avoided wherever possible, and under no circumstances should it become customary. When overtime work exceeds a few consecutive days, the continued mental fatigue causes employees to slow down to a point where the overtime does not produce increased output. Quality of work rapidly deteriorates when employees are subjected to a continued overtime schedule.

However, there are occasions where overtime is necessary, but all such work should receive the chief engineer's approval and be authorized only in cases where there is no other possible manner of accomplishing the required work. A definite procedure for requesting and authorizing overtime is necessary when the department is large enough to require full-time supervisors.

Another problem present in every department is control of employees who must visit factory departments in connection with engineering work. The prerogative of freely visiting other departments cannot be extended to all engineering employees, for there are always a few who will take advantage of the privilege. In a large department it is feasible to inaugurate a "shop-pass" system, such as that described in Chap. 3. In small departments it usually suffices to require that all employees leaving the engineering department sign a register noting the time of their departure and destination, followed by entering the time of their return. This procedure not only tends to eliminate extended visits to other departments but also makes it possible to locate engineering employees who are visiting other departments.

CONTROLLING THE WORK FLOW

Basic control of the work flowing through the engineering department is a responsibility of the engineering planning activity, which schedules the work to be in process at any given time. Detail control is accomplished by establishing simple, practicable *methods* for physical handling and recording of work during its course through the engineering department. This involves establishing methods to control

1. Preparation of drawings
2. Drawing numbers
3. Drawing release
4. Distribution of engineering data
5. Advance information
6. Drawing changes
7. Master-parts lists
8. Liaison with factory

These are the major factors involved in the physical preparation and release of drawing information and are the engineering activities most apparent to other departments.

DRAWING PREPARATION

In every engineering department, irrespective of size, there is need for standardizing the preparation of drawings from the consideration of *what* should appear on drawings. Large engineering departments usually issue a *drafting-room manual* or *engineering manual* (see Chap. 6) to every new employee. This publication defines and illustrates the exact manner of preparing drawings that will be acceptable to the checkers.

Although small engineering groups do not justify the expense of preparing an elaborate manual, it is still necessary to define clearly basic requirements for drawing preparation and issue copies of these instructions to every draftsman. These data may comprise only a few mimeographed sheets but will be effective if they define the department's standard organization; drawing sizes, scales, titles, and notes; methods of specifying materials, dimensioning, and calling out parts requirements; and procedure for releasing drawings. The best possible method of presenting this information in a small engineering group is through brief printed instructions, supplemented with a few well-chosen specimen drawings that illustrate common conditions encountered during preparation of drawings.

It is vitally necessary to establish and maintain a master numbers book, in which are recorded numbers for all drawings. This should be made the responsibility of some one member of the department. Under no circumstances should the numbers book be available to the drafts-

men, with dependence placed upon each employee's making proper entries in the book when using the next available number. This practice is certain to lead to costly errors arising from failure to record numbers and from the use of the identical number on more than one drawing. Centralized control of drawing numbers is even more important when the numbering system is "coded," where the number indicates the nature of the part shown on the drawing. Unless rigid control is maintained over issuance of numbers in these cases, the "coded" system will end in complete confusion. See Chap. 7 for detail information regarding drawing numbers and numbers books.

DRAWING RELEASE

It is necessary always to know the exact nature of all drawings that have been completed, checked, approved, and released by the engineering department. These must be listed by number, date, and revision in a manner that provides for rapid reference. In Chap. 9 is given detail information on a drawing-release procedure that provides adequate control for any engineering department.

As the department becomes smaller and the articles designed simpler, the requirements for checking and approval become less complex, but the basic records remain substantially the same. The job ticket can be eliminated (using only the release request), as described in Chap. 9 under Drawing Release in a Small Engineering Department.

In any case the drawing release system should provide (1) authority for releasing the drawing, (2) design approval of the drawing, (3) a record of all change requests and advance engineering information incorporated in each change, (4) a record by change letter and date of each release of the drawing, (5) a record of the serial number and destination of each print made of the released drawing, and (6) delivery acknowledgment from each recipient of prints.

A positive control must be established over the release of engineering data in order to avoid the possibility of other departments' working to obsolete drawings or specifications. All drawing and report revisions should be identified by change letters or revision numbers (preferably the former), and a procedure should be established for automatically supplying a copy of each revision to all holders of previous releases (see Chaps. 10 and 14). The importance of maintaining rigid control over the release of engineering data cannot be overemphasized because manufacturing parts to obsolete drawings can be extremely costly.

All copies of drawings, specifications, and reports issued by the engineering department should be provided with *individual* identity. This

can be easily accomplished by assigning to each a serial number providing both numerical identification and record of the revision letter (see Chap. 10 for details).

A record of the distribution of engineering data must be maintained, showing for each drawing, report, and specification the date of the original distribution, the destination of each copy, and the subsequent distribution of all copies of revised issues. A shipping notice or invoice should accompany each shipment of engineering data to every destination. This notice should be prepared in duplicate with one copy to be signed by the recipient and returned as acknowledgment of delivery. This practice should be followed for data delivered both to other departments within the company and to destinations outside the company. Although this may appear to be unnecessary "system," it is the *only* method of placing the responsibility for working to the latest engineering data squarely where it belongs—upon the person receiving the data.

ADVANCE INFORMATION

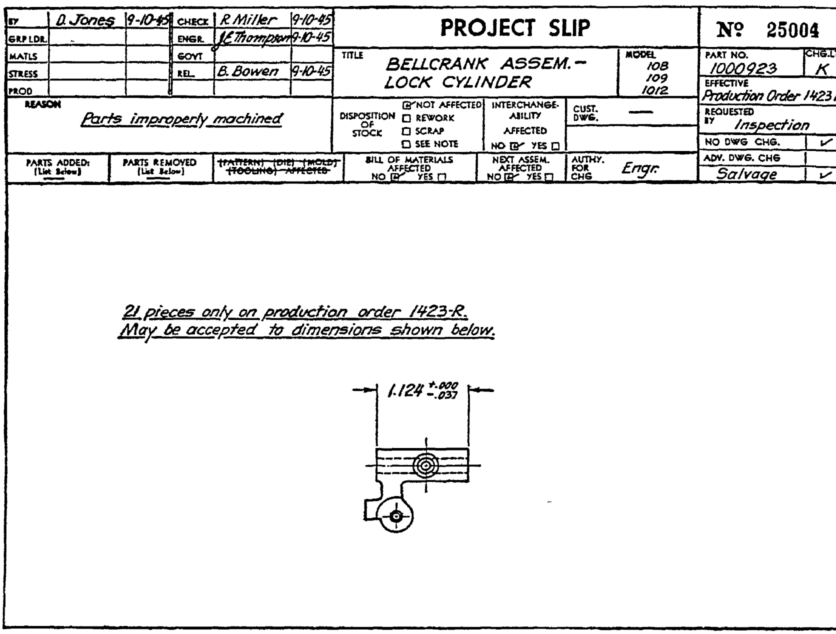
Issuance of engineering information in advance of actual drawings can lead to endless confusion and misunderstanding unless it is properly controlled and authorized. When properly handled this practice can effect large savings by expediting construction of experimental articles and facilitating changes during production.

Control is readily established by issuing advance information in a standardized manner, subject to definite centralized approval and with complete records of its distribution. See Chap. 11 for a description of a system involving usage of *stop orders*, *advance drawing changes*, and *engineering orders*.

The method described in Chap. 11 requires three separate forms to convey advance information. Use of separate forms is considered mandatory when advance information is issued frequently. Separate forms facilitate individual records for each type of information and minimize the possibility of manufacturing departments misunderstanding the purpose of advance information.

Small engineering departments have correspondingly small need for advance drawing changes. In a majority of cases the drawing itself can be quickly revised, followed by rapid distribution of revised prints. The principal uses of advance information will be authorization of drawing deviations, special tests, and salvage rework. In most cases for issuance of all types of advance engineering information, a small engineering department can use a single form similar to the project slip shown in Fig. 15:4.

Project slips are prepared in the same manner as advance drawing changes and engineering orders (see Chap. 11). The title block provides for indicating the nature of the project slip (PS). When the "No Dwg Chg" space is checked, the PS is in the nature of an engineering order, and the information given is likely to be a drawing deviation or special test instructions and will *not* be incorporated in a drawing. When the



PROJECT SLIP

Nº 25004

BY	D. Jones	9-10-45	CHECK	R. Miller	9-10-45
GRP LDR.			ENGR.	J.E. Thompson	9-10-45
MATLS			GOVT		
STRESS			REL.	B. Bowen	9-10-45
PROD					

TITLE: BELLCRANK ASSEM.—LOCK CYLINDER
MODEL: 108, 109, 1012
PART NO.: 1000923 CHG. LTR.: K
EFFECTIVE: Production Order 1423 R
REASON: Parts improperly machined
DISPOSITION OF STOCK: ☑ NOT AFFECTED ☐ REWORK ☐ SCRAP ☐ SEE NOTE
INTERCHANGEABILITY AFFECTED: NO ☑ YES ☐
CUST. DWG. —
REQUESTED BY: Inspection
NO DWG. CHG. ✓
PARTS ADDED: (List Below)
PARTS REMOVED (List Below)
~~(PATTERN) (DIE) (MOLD) (TOOLING) AFFECTED~~
BILL OF MATERIALS AFFECTED NO ☑ YES ☐
NEXT ASSEM. AFFECTED NO ☑ YES ☐
AUTHY. FOR CHG: Engr.
ADV. DWG. CHG
Salvage ✓

21 pieces only on production order 1423-R.
May be accepted to dimensions shown below.

FIG. 15:4.—Project Slip, an 8½- by 11-in. reproduceable form used to authorize and issue advance engineering information.

"Adv Dwg Chg" space is checked, the PS is an advance drawing change, and the information will be added during the next drawing revision (see Chap. 12). The PS form is also used as a stop order, stop release order, and salvage order by entering the appropriate title in the blank space at the lower, right corner of the title block.

DRAWING CHANGES

Drawing changes are a normal portion of engineering-department operation, and it is necessary to establish orderly methods for requesting, accomplishing, and recording these revisions. The first consideration requires a formal method for other departments to request drawing

changes—one that will insure proper, prompt action in all cases. The second involves a logical, efficient system of preparing and identifying drawing revisions.

A drawing change-request form should be provided even in the smallest engineering department. This need not be elaborate, and its basic requirements are (1) identification of the drawing to be changed, (2) statements of the change desired and the reason for the request, (3) an identifying *serial number* for the change request, (4) a copy of the request to be retained by the originator, and (5) an additional copy to be returned to the originator with notation of the action to be taken by engineering.

Use of change-request (CR) serial numbers is important. Consistent, rapid action on requested changes is dependent upon recording these in a manner that provides individual indentity. When this is done, it becomes a simple matter to maintain an active follow-up system to expedite rapid disposition of all change requests. Each time that a drawing is changed, it is possible to check for incorporation of all approved change requests. See Chap. 12 for detail information on change-request procedure.

A definite procedure for handling drawing changes is necessary in order to insure efficient, accurate revisions. This should establish methods for (1) preparing the drawing revision; (2) identifying the drawing location of changes; (3) listing all change requests and advance information incorporated in the revision, (4) identifying the revision by date and letter (or number) in a specified location on the drawing, (5) detailing nature, reason, and effectivity of each change item in a notice of change; and (6) checking and approving the revised drawing and its notice of change prior to release of changed prints.

A separate notice of change for each drawing revision is considered preferable to the use of an alteration block in a corner of the drawing sheet. An alteration block providing adequate space for complete information is unreasonably large, particularly on smaller drawings. Ample space can be provided on a 5- by 8- or 8½- by 11-in. notice-of-change form. Only the current notice is attached to prints, avoiding accumulation on the prints of useless "ancient history." If the notice is prepared on tracing paper, it is practicable to print this on the margin of revised prints so that the notice becomes a physical part of each print.

MASTER-PARTS LIST

A master-parts list is required whenever the engineering drawings describe units comprising subassemblies and detail parts. This is necessary to guide other departments in ordering materials, fabricating proper

quantities of parts, and correctly assembling finished articles. Preparation and issuance of accurate, up-to-date master-parts lists is equal in importance to preparing drawings and is a proper function of the engineering department. When a master-parts list (MPL) is properly arranged, its preparation, revision, and distribution should not involve additional engineering expense, since an MPL combines the data from two documents usually originated in engineering: bill of materials and parts catalogue. These are not required when a proper MPL is used. See Chap. 13 for specimen master-parts list.

Actual arrangement of the MPL form is not important, provided it lists all parts required to form the complete article—showing the approximate order and sequence of their assembly—and lists the quantity required and material for each. Although the MPL is issued separately from the drawings, it should be considered a part of the drawings and revised whenever a drawing is changed. Copies of the revised parts-list pages should accompany the revised drawing prints.

Master-parts lists should be supplied all departments concerned with material procurement and fabrication for the articles described by engineering drawings. Each person concerned with manufacture of the articles will then be working to identical technical information, avoiding errors arising from individual interpretation of drawing material requirements and assembly sequences.

LIAISON

Engineering problems do not end, regrettably, with completion of the initial release of a set of drawings describing a particular article. Throughout production of the article there will be continued requests for drawing interpretation, additional information, drawing changes to facilitate production, and advice on the proper method of salvaging incorrectly manufactured parts. This results in a constant flow of requests to and information from the engineering department.

Unless these requests are channeled through a specified point, there will be needless duplication of effort and frequent release of erroneous or confusing engineering information. Such a condition is obviously intolerable, for on the one hand it increases engineering expense and on the other produces interdepartmental discord.

The solution to this problem is simple. A member of the engineering department, designated as liaison engineer, is assigned to receive all incoming requests, obtain the information to answer these, and forward the data to the requesters. Such an arrangement will work very well, *if a competent person is chosen as liaison engineer,* when a genuine effort

is made to see that all requests are quickly answered. Speedy handling of requests can be achieved by delegating to the liaison engineer authority to decide a majority of requests without his having to obtain approval of the answer. This is feasible when the liaison engineer's ability is equal to or better than that of the average project engineer.

MAINTAINING THE SCHEDULE

All organization, planning, personnel control, methods improvement, and the like aim toward a single goal—completion of engineering assignments within allowed budgets of time and money. The only purpose in carefully organizing and controlling departmental operations is to insure achievement of this end.

When planning is based upon sound estimating and realistic concept of the time required to accomplish engineering work, then maintaining schedule is largely a matter of daily comparison of actual with scheduled progress, with corrective action applied whenever and wherever work is behind schedule. Illness, dismissal, or training of employees are not acceptable reasons for failure to meet a schedule. These conditions are likely to arise during the course of any project, and suitable allowances must be made in the original schedule. Only major disasters beyond control of engineering are valid reasons for failing to meet a schedule.

The causes of lagging schedules are few: insufficient manpower, failure to apply available manpower properly, incorrect original estimates, unnecessary work, engineering error, or incompetent leadership. All except the first are in reality a reflection of one—incompetent leadership. In every case the cause can be readily ascertained, and the solution is usually obvious.

Another cause of lagging schedules is extensive redesign due to customer requested changes. This is not controllable by engineering except to the extent of demanding that the customer agree to extension of the project completion date in cases where accomplishment of the requested changes will make it impossible to meet the original schedule.

APPENDIX I

TYPICAL ENGINEERING COST AND TIME CHARGE PROCEDURE

The procedure used by a large western company to accumulate engineering costs of airplane designs employs a detailed breakdown of departmental operations on each project. A modified form of their procedure is presented here. It involves a *work order* to authorize work on each project, *code numbers* to classify main subdivisions of the work, and *serial numbers* to identify each piece of work.

The system is basic, and its application is not confined to aircraft manufacturing. The serial-number breakdown is the essence of the system. It is a simple matter to establish serial numbers that will describe the products manufactured regardless of their nature. A comprehensive breakdown can also be used, in conjunction with departmental code numbers for cost accumulation throughout the company. Thus, the cost of parts and complete articles can be accumulated throughout all manufacturing operations—beginning in engineering and following through manufacturing planning, tooling, fabrication, assembly, inspection, test, and shipping. Nonproductive costs, such as sales and service expenses, can also be accumulated against the related parts, assemblies, and complete articles.

ACCUMULATING ENGINEERING COSTS

A daily *time-distribution record* is prepared by each engineering employee, using applicable work-order, code, and serial numbers to identify and segregate time distribution during the working period. This record is forwarded to Engineering Planning at the close of each working day, checked for accuracy of entries, and then sent to engineering cost control for recording and tabulating. Time is recorded in increments of $\frac{1}{10}$ hr., and an engineering-planning representative checks with every engineering employee during the morning and afternoon of each working day in order to verify correctness of the time charges being used. This frequent, centralized checking of time charges used by employees insures the correctness of engineering cost-control data. Responsibility for this checking is assigned to Engineering Planning as this activity is familiar with the nature of all authorized engineering work.

a. A *work-order number* is used to authorize the expenditure of engineering time. This number consists of two parts: a prefix of the *project number* indicating the airplane model and a dash suffix identifying the individual work order. Thus, work order 19—1 is the first order issued to authorize work on project 19. A specimen list of work orders appears on page 312.

b. *Code numbers* are used to indicate the general nature of the work. A list of code numbers appears on page 312.

c. A *serial number* is used to identify the exact nature of the work accomplished and the portion of the airplane affected. A list of serial numbers follows page 313.

TIME-DISTRIBUTION RECORD

The following examples of time-distribution record entries illustrate the use of this time-charge procedure:

a. The employee spent a full 8-hr. day preparing a layout drawing of fuselage removable side panels for the D2R airplane.

TIME-DISTRIBUTION RECORD

Employee John E. Burns Clock No. 2-125

Department 2 Date 9/24/45

Start / End	Elapsed time	Work order	Code No.	Serial No.
8:00 A.M. / 5:00 P.M.	8	19—1	500	1107

b. Following completion of the fuselage side-panel layout drawing for the D2R, another employee began detail and assembly drawings required to manufacture the side panels. Eight hours spent on this task is recorded as follows:

TIME-DISTRIBUTION RECORD

Employee D. R. Jacobs Clock No. 2-361

Department 2 Date 10/5/45

Start / End	Elapsed time	Work order	Code No.	Serial No.
8:00 A.M. / 5:00 P.M.	8	19—1	500	1507

c. In this case the employee worked 3 hr. overtime on development engineering relating to landing-gear redesign for the model D2R airplane.

TIME-DISTRIBUTION RECORD

Employee Ralph L. Miller — Clock No. 2-76

Department 2 — Date 9/27/45

Start / End	Elapsed time	Work order	Code No.	Serial No.
8:00 A.M. / 9:00 P.M.	11	19—6	500	5001

d. Structural testing of D2R wing compression and tension joints, followed by D5R landing-gear structural tests, occupied this employee's attention for an entire day.

TIME-DISTRIBUTION RECORD

Employee Wesley R. Stevens — Clock No. 2-43

Department 2 — Date 10/3/45

Start / End	Elapsed time	Work order	Code No.	Serial No.
8:00 A.M. / 11:30 A.M.	3½	19—1	501	2007
11:30 A.M. / 5:00 P.M.	4½	34—2	501	5007

VACATIONS AND IDLE TIME

A time-distribution record is prepared by each employee for every working day, and the total elapsed time shown on this record must equal the full workday plus authorized overtime. Special work orders are established for the accumulation of vacation time and "idle time." Idle time is usually the result of defective group supervision and results when the supervisor fails to plan a new assignment prior to the time an employee completes a current task. The percentage of idle time is a good indication of the supervisor's efficiency and is carefully recorded and tabulated for the information of engineering top management.

ENGINEERING WORK ORDERS

The following examples of engineering work orders illustrate the relationship between project number and project dash-number portions of the order number. These identify the model and the expenditure authorized by the work order.

Work order No.	Model	Nature of work
19—1	D2R	Production contract for 100 airplanes
19—2	D2R	Calculation of dynamic balance
19—3	D2R	Preparation of master-parts list
19—4	D2R	Preparation of handbook revisions
19—5	D2R	Production improvement changes
19—6	D2R	Redesign of landing gear
19—7	D2R	Redesign of armament
19—8	D2R	Alternative engine installation—GE I—47
34—1	D5R	Experimental contract for 3 airplanes
34—2	D5R	Engineering on static test airplane
34—3	D5R	Redesign of empennage

CODE NUMBERS

The code numbers can be extended to accommodate any desired subdivision of costs, and the list given here represents a practical minimum. Determination of the maximum detail desired in cost accumulation is a matter for top-management decision. Cost control can easily be extended to a point where the expense of accumulating cost data absorbs savings accruing from knowledge of cost origin, nature, and cause. In general, cost control should be expanded in direct ratio to the company's growth. The possibility that neglected minor cost items may develop into major expenses becomes increasingly likely as the company pay roll is enlarged.

Code Number	Work Classification
500	Airplane design
501	Research and test
502	Wind-tunnel model
503	Mock-up
504	Flight test
505	Technical services
506	General services

SERIAL NUMBERS

The functional serial-number breakdown given here is sufficient to allow satisfactory detailed cost accumulation in most cases. The general serial numbers at the beginning of each functional group permit accumulating general costs. When more detailed cost accumulation is desired, this can be accomplished by assigning code

numbers to identify general costs, or one of the unused serial number groups may be employed, as described below.

Serial numbers from 1000 to 9999 relate to engineering work on major functional groups of the airplane. These serial numbers comprise three significant parts. The first digit indicates the airplane functional group:

1000	Fuselage	4000	Controls	7000	Instruments
2000	Wing	5000	Landing gear	8000	Electrical and equipment
3000	Empennage	6000	Power plant	9000	Armament

The second digit indicates the kind of work accomplished:

0000	Supervision and general	0500	Detail drawings
0100	Layout drawings	0600	Checking of drawings
0200 through 0400	Reserved for future use	0700	Stress analysis
		0800	Weight analysis
		0900	Reserved for future use

The last two digits of the serial number identify the portion of the airplane and are constant throughout all phases of engineering. For instance, the designer preparing the fuselage removable side-panel layout drawing charges time to serial number 1107; the draftsman preparing detail manufacturing drawings of these side panels will charge time to 1507. When the detail drawings are placed in the system, the checker will charge the time spent in checking these detail drawings to 1607; the stress analyst approving the drawings will charge time to 1707; and the weight analyst will charge time to 1807.

Each functional serial-number group begins with a listing of general time charges, and the numbers between 0000 and 0099 of each group are assigned to that purpose. Continuity is established by maintaining identical significance for these serial numbers, regardless of the functional group. Thus, serial number 1005 indicates lofting work relating to the fuselage; 2005, lofting for the wing; 3005, lofting for the empennage; etc.

A specimen list of serial numbers for the fuselage of a fictitious airplane model is given here. Similar listings of significant major assembly drawings are prepared for each major functional group in order to establish a complete schedule of serial numbers. A separate serial-number list must be prepared for each new model since changes in the basic arrangement of the article alter the major assembly drawings required.

Fuselage Serial Numbers

Serial No.	Description of Work
	General serial numbers:
1000	Supervision
1001	Development engineering
1003	Stress analysis
1005	Lofting
1006	Template
1007	Structural testing
1008	Clerical
1009	Liaison
1010	Minor drawing changes (less than ½ hr.)
1011	Tracing
1013	Mock-up design

FUSELAGE SERIAL NUMBERS.—(*Continued*)

Serial No.	Description of Work
Layout serial numbers:	
1100	Master diagram—forward fuselage
1101	Fuselage assembly—forward
1102	Weld assembly—forward fuselage
1103	Fairing assembly—forward fuselage
1104	Master diagram—aft fuselage
1105	Fuselage assembly—aft
1106	Panel assembly—aft fuselage side
1107	Panel assembly—forward fuselage removable
1108	Longeron assembly—aft fuselage
1109	Fairing assembly—fuselage sta. 412
1110	Deck assembly—fuselage sta. 374 to 415
1111	Structure assembly—fuselage fairing
1112	Enclosure assembly—fuselage sta. 82 to 167
1113	Bulkhead assembly—aft fuselage sta. 412
1114	Bulkhead assembly—top panel
1115	Bulkhead assembly—lower panel
1116	Bulkhead assembly—upper
1117	Bulkhead assembly—bottom
1118	Fitting assembly—sta. 374 fin attachment
1119	Door assembly—side-panel access
1120	Skid assembly—tail
1121	Bulkhead assembly—sta. 374
1122	Longeron assembly—aft fuselage lower
1123	Tube assembly—fuselage forward carry-through
1124	Tube assembly—fuselage aft carry-through
1125	Hook assembly—fuselage tow
1126	Cap assembly—nose
1127	Hoisting assembly—airplane
1128	Skin assembly—aft fuselage left side
1129	Skin assembly—aft fuselage right side
1130	Installation—servo clutch supports
1131	Link assembly—catapult hooks
1132 through 1199	Unused fuselage layout serial numbers
1500 through 1599	Detail and assembly drawings—fuselage
1600 through 1699	Drawing checking serial numbers—fuselage
1700 through 1799	Stress-analysis serial numbers—fuselage
1800 through 1899	Weight-analysis serial numbers—fuselage

Functional serial numbers in the 0200, 0300, 0400, and 0900 groups are unassigned and can be used for additional detail breakdown of time expenditures. For instance, should a detail breakdown of lofting time be required, the 0200-serial number group can be used for this purpose. In that case the designer preparing layout drawings for the forward fuselage assembly charges time to serial 1101, and the loftsman working on forward fuselage lines will charge time to 1201. The draftsman preparing manufacturing drawings of the forward fuselage charges time to 1501; the checker, to 1601; stress analyst, to 1701; and the weight analyst, to 1801.

Serial numbers from 10,000 up are used to identify various engineering work not directly connected with the preparation of manufacturing drawings. Thus:

11,000	Miscellaneous	14,000	Technical services
12,000	Aerodynamics and thermodynamics	16,000	General services
13,000	Process engineering	18,000	Tool design

Serial-number groups omitted from these "nondrafting" schedules are unassigned and reserved for future use should additional time charges be required.

The schedules shown on the following pages do not pretend to be complete, in the sense that they can be applied without modification to all engineering departments. Instead, they indicate the nature of suitable serial-number schedules for nondrafting work.

MISCELLANEOUS ENGINEERING SERIAL NUMBERS

Serial No.	Description of Work
11,000	Supervision of project
11,001	Development engineering—miscellaneous
11,003	Stress analysis—miscellaneous
11,005	Lofting—miscellaneous
11,006	Template—miscellaneous
11,007	Structural testing—miscellaneous
11,008	Clerical—miscellaneous
11,009	Liaison—miscellaneous
11,010	Changes—miscellaneous
11,011	Tracing—miscellaneous
11,013	Mock-up—miscellaneous
11,201	Layout—wing master coordination
11,202	Layout—fuselage master coordination
11,500	Three-view drawing
11,501	Inboard profile
11,502	Diagram—fixed equipment
11,503	Diagram—useful load
11,504	Diagram—paint and insignia
11,600	Checking—miscellaneous
11,800	Weight analysis—miscellaneous

AERODYNAMICS AND THERMODYNAMICS SERIAL NUMBERS

Serial No.	Description of Work
12,000	Aerodynamics—supervision
12,101	Aerodynamics—proposal
12,103	Aerodynamics—development engineering
12,105	Aerodynamics—production
12,107	Aerodynamics—sales
12,110	Performance—research
12,111	Performance—engineering
12,114	Stability and control—research
12,115	Stability and control—engineering
12,118	Wing design and aerodynamic loads—research
12,119	Wing design and aerodynamic loads—engineering
12,122	Flutter—research
12,123	Flutter—engineering
12,126	Vibration—research
12,127	Vibration—engineering
12,201	Reports—aerodynamic
12,210	Aerodynamic research—miscellaneous
12,211	Aerodynamic design—miscellaneous
12,214	Aerodynamic testing—miscellaneous
12,250	Instrumentation
12,302	Photographic—aerodynamics
12,303	Stenographic—aerodynamics
12,400	Wind tunnel—supervision
12,401	Wind tunnel—design
12,402	Wind tunnel—testing and calibration
12,403	Wind tunnel—research
12,600	Supervision—flight test
12,601	Preparation—flight test
12,602	Operations—flight test
12,603	Analysis—flight test
12,605	Reports—flight test
12,607	Research—flight test
12,608	Flight—production shakedown
12,609	Flight—sales and advertising
12,700	Supervision—thermodynamics
12,710	Cooling—research
12,711	Cooling—engineering
12,714	Cooling tests—miscellaneous
12,720	Power plant—technical problems
12,721	Power plant—tunnel testing
12,730	Flow investigations
12,740	Analysis—engine installations
12,750	Reports—thermodynamics
12,762	Photographic—thermodynamics
12,763	Stenographic—thermodynamics

Process Engineering Serial Numbers

Serial No.	Description of Work
13,000	Supervision—process engineering
13,500	Process specification—technical data
13,501	Process specification—tracing and art
13,502	Process specification—photographic
13,503	Process specification—stenographic
13,504	Process specification—supervision
13,510	Finish specification—technical data
13,501	Finish specification—tracing and art
13,502	Finish specification—photographic
13,503	Finish specification—stenographic
13,504	Finish specification—supervision
13,601	Process research
13,602	Process testing

Technical Services Serial Numbers

Serial No.	Description of Work
14,000	Supervision—technical services
14,010	Specifications—technical data
14,011	Specifications—tracing and art
14,012	Specifications—photographic
14,013	Specifications—stenographic
14,014	Specifications—supervision
14,020	Erection and maintenance manual—technical data
14,021	Erection and maintenance manual—tracing and art
14,022	Erection and maintenance manual—photographic
14,023	Erection and maintenance manual—stenographic
14,024	Erection and maintenance manual—supervision
14,030	Pilot's handbook—technical data
14,031	Pilot's handbook—tracing and art
14,032	Pilot's handbook—photographic
14,033	Pilot's handbook—stenographic
14,034	Pilot's handbook—supervision
14,040	Repair handbook—technical data
14,041	Repair handbook—tracing and art
14,042	Repair handbook—photographic
14,043	Repair handbook—stenographic
14,044	Repair handbook—supervision
14,050	General sales and service—technical data
14,051	General sales and service—tracing and art
14,052	General sales and service—photographic
14,053	General sales and service—stenographic
14,060	Design information data—technical data
14,061	Design information data—tracing and art
14,062	Design information data—photographic
14,063	Design information data—stenographic
14,064	Design information data—supervision

TECHNICAL SERVICES SERIAL NUMBERS.—(*Continued*)

Serial No.	Description of Work
14,070	Drafting-room manual—technical data
14,071	Drafting-room manual—tracing and art
14,072	Drafting-room manual—photographic
14,073	Drafting-room manual—stenographic
14,074	Drafting-room manual—supervision
14,100	Engineering planning
14,200	Engineering cost control
14,210	Engineering cost analysis
14,300	Service bulletins—technical data
14,301	Service bulletins—tracing and art
14,302	Service bulletins—photographic
14,303	Service bulletins—stenographic
14,304	Service bulletins—supervision
14,400	Illustration for engineering—miscellaneous
14,401	Illustration for other departments

GENERAL SERVICES SERIAL NUMBERS

Serial No.	Description of Work
16,000	Supervision—general services
16,010	Master-parts list—compiling
16,013	Master-parts list—stenographic
16,014	Master-parts list—supervision
16,020	Parts catalogue—compiling
16,021	Parts catalogue—tracing and art
16,022	Parts catalogue—photographic
16,023	Parts catalogue—stenographic
16,024	Parts catalogue—supervision
16,030	Spare-parts list—compiling
16,033	Spare-parts list—stenographic
16,034	Spare-parts list—supervision
16,100	Blueprinting
16,101	Vandykes and duplicate tracings
16,102	Blueprint for manufacturing planning
16,103	Blueprint for tool design
16,104	Blueprint for purchasing
16,200	Engineering personnel control
16,201	Absence and tardiness deficiency time
16,202	Vacation
16,203	Holiday
16,204	Time out approved by company
16,205	Medical examination and first aid
16,206	Idle time
16,207	Induction time
16,300	Photographic for engineering—miscellaneous
16,301	Photographic for other departments

General Services Serial Numbers.—(*Continued*)

Serial No.	Description of Work
16,400	Engineering library
16,500	Engineering files
16,600	Engineering release—drawings
16,700	Timekeeping—engineering

Tool-design Serial Numbers

Serial No.	Description of Work
18,000	Tool design—supervision
18,050	Tool design—miscellaneous
18,100	Tool design—fuselage
18,200	Tool design—wing
18,300	Tool design—empennage
18,400	Tool design—controls
18,500	Tool design—landing gear
18,600	Tool design—power plant
18,700	Tool design—instruments
18,800	Tool design—electrical and equipment
18,900	Tool design—armament

It is immediately apparent that each of the tool-design functional group serial numbers can be subdivided to provide 100 detail time charges. These can be arranged to correspond with functional serial numbers for layout drawings when it is considered desirable to segregate tool-design costs completely.

APPENDIX II

TYPICAL COST-ANALYSIS INVESTIGATIONS

In this appendix are shown cost comparisons and design-change investigations typical of an aggressive cost-reduction program. They are useful criterions of comparative costs of similar designs; for although money values will change with labor and material fluctuations, the proportional costs of alternative designs will remain substantially the same.

Major cost reductions involving large sums are rarely found after a design is completed. These are usually so obvious that the proper method is apparent, even to a designer with a casual awareness of the effect of design upon manufacturing cost. Instead, the success of a cost-reduction program results from obtaining the lowest cost that is compatible with maintaining product quality for each part. Saving pennies on each part soon represents many dollars in the cost of manufacturing the complete article. The prime factors governing the cost of a part are

Material	Assembly or installation time
Manufacturing requirements	Engineering expense
Quantity	Tooling expense
Machining or fabricating time	Ease of maintenance

MATERIAL

Material should be selected with due consideration of (1) strength requirements, (2) weight requirements, (3) service requirements, (4) raw-stock form, (5) availability, (6) delivery, and (7) cost.

a. Service requirements relate to the part's use, and care must be used to avoid selecting materials entirely unsuited to the task performed. Magnesium may appear to be ideal; but if the product is to be subjected to salt-air corrosion, the use of this material should be discouraged. Magnesium is also desirable from strength and weight considerations for hydraulic actuating-cylinder and selector-valve parts, but again service conditions may prohibit its use. Certain hydraulic oils rapidly corrode magnesium parts—even when treated by the best current corrosion-preventative process. Parts subject to handling damage must not be made from a brittle material, use of aluminum-alloy die-castings being preferable where a molded plastic would otherwise be used. In each case a study of the part's operating conditions will establish the relative desirability of the possible materials.

b. Raw-stock form has considerable influence upon cost. Many cylindrical parts can be produced from either rod or heavy-wall tubing. In most cases rod will provide the lowest manufacturing cost when the material is alloy steel. On the other hand, heavy-wall tubing is generally preferable when the material is carbon steel. Simple light-metal structural sections can usually be obtained as either extrusions

or rolled sections, but often the extrusion will cost more. Extrusions, however, are generally more economical for complicated structural sections.

c. The material's availability should be investigated. Many sizes of rod, bar, and tubing are obtainable only in special mill shipments. This introduces delivery delay, and special mill runs increase the material's unit cost.

d. Material deliveries must be coordinated with production schedules. This often makes a sand-casting preferable to a die-casting or forging. Die-castings and forgings require precision metal dies, laboriously "carved" from blocks of tool steel, whereas wood patterns for sand-molding are quickly produced.

MANUFACTURING REQUIREMENTS

All machine tools and metalworking equipment required to fabricate the part should be available within the company. If they are not, an effort should be made to develop a design that can be produced with company equipment. Although it is true that additional equipment can be obtained or the part subcontracted, these practices are not always desirable. Procurement of additional equipment may involve purchase of an expensive machine that cannot be efficiently utilized throughout the work period. Subcontracted parts are always expensive owing to the addition of a subcontractor's overhead and profit to the basic part cost.

QUANTITY

The quantity manufactured has a great influence upon cost. When the quantity is small (less than 100), the cost of die-castings and forgings grows prohibitive, and the use of sand- or permanent-mold castings becomes mandatory. Only in cases where strength considerations are extreme should forgings be considered for limited production. Even then consideration should be given to the possibilities of using weld assemblies, centrifugal castings, or heat-treated sand-castings. In cases involving a few parts it may be economical to machine parts from billets rather than incur the expense of forging dies.

The quantity required can frequently be doubled, with substantial reduction in raw-stock material cost, by combining left- and right-hand opposite parts into one rough forging. The rough-forging design can often be altered slightly to permit machining both "hands" from the same blank. There are also cases where slight design alterations will permit machining several similar parts from one rough forging. Machining operations will be slightly different for each, but sufficient stock is provided in the rough forging to accommodate these differences.

MACHINING AND ASSEMBLY TIME

All unnecessary machining and fabricating must be avoided. A common error is curved surfaces to improve the appearance of a part that is actually hidden from view when the article is completed. Constant vigilance should be exercised in order to avoid unnecessarily complicated fabricating operations. For instance, a part blanked from sheet metal may involve inside corners requiring a shear die. Study of such parts often reveals a method of eliminating the inside corners, permitting blanking by straight-shear operations. Bend reliefs at the corners of bent-up sections are often unnecessarily complicated. In most cases a straight-shear cut that clears the bend radius 45 deg. to the bend-lines will be satisfactory.

Assembly and installation cost must not be neglected, and every effort should be made to eliminate designs requiring complicated, time-consuming operations. A part may not be expensive in itself but may require a costly assembly operation. Thus, it may occasionally be found economical to use a design having a higher fabrication cost if this is compensated by reduced assembly expense. Care should be used when comparing costs of purchased parts and equipment as the initial purchase price does not always reflect the actual, installed cost. One product may require additional parts or fittings to become a true equivalent of another manufacturer's article.

ENGINEERING EXPENSE

Design changes to reduce manufacturing cost may not be desirable if considerable engineering time is involved. When the gross saving is small, it may be found that design and drafting time, coupled with drawing-change expense and the cost of releasing new blueprints, is perhaps sufficient to absorb the manufacturing saving. This is often the case when small quantities are involved because the unit engineering expense is directly proportional to part quantity.

Disposal of obsolete material should also be considered when planning changes to reduce manufacturing cost. Obsolete material and equipment are often a total loss, for only in a few cases can they be returned to the vendor for credit. Material that cannot be returned must either be carried as obsolete inventory or sold as surplus. The returns realized through surplus sales are usually quite low. Disposal of material obsoleted by the change may result in a loss greater than the saving shown for the cost improvement.

TOOLING EXPENSE

Comparative cost investigations and cost-reduction programs should always consider the tooling expense involved. Tool-design and manufacturing expenses for small quantities of parts may have a vital effect on the net costs of comparative designs. When large quantities are involved, the unit tooling cost is proportionately lower, and this factor is less important.

Cost-reduction programs should consider the cost of scrapping and reworking existing production tooling to accommodate design changes. Scrapping or reworking extensive tooling may easily absorb the entire production saving.

EASE OF MAINTENANCE

The success of a product is ultimately determined by customer satisfaction. Low maintenance expense is important in developing customer satisfaction. Freedom from service difficulties and ease of maintenance should be considered major factors in all cost-improvement studies. Changes for the sake of an immediate production saving should not be permitted when there is possibility of compromising the product's serviceability.

TYPICAL COST ANALYSES

The remainder of this appendix presents cost analyses of typical industrial parts (see Figs. 1 through 12), that demonstrate many of the basic factors discussed here. Engineering expense is not included because this is a factor only when changing an

existing, completed design. It should be remembered that although money values will vary with changes in labor and matériel costs, the comparative costs of alternative designs will remain substantially the same.

Kind of Part. Release pawl
Quantity. 500
Nature of Change. From 17ST aluminum-alloy bar-stock machined part to manganese-bronze die-casting
Effect on Weight. 0.18 lb. increase

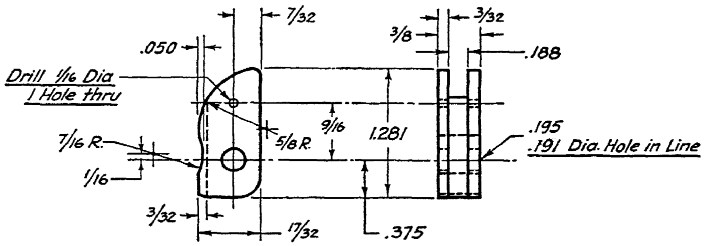


FIG. 1.

Original Design. 17ST aluminum-alloy bar stock:

Material	$0.03
Labor	0.60
Unit cost	$0.63

New Design. Manganese bronze die-casting:

Die	$0.23
Casting (completely finished)	0.30
Unit cost	$0.53

Remarks. The total die cost remains fixed, resulting in decreased unit die cost if the part quantity increases.

Kind of Part. Miscellaneous brackets
Quantity. 3,500 each
Nature of Change. From sand-casting to die-casting, using equivalent material
Effect on Weight. None

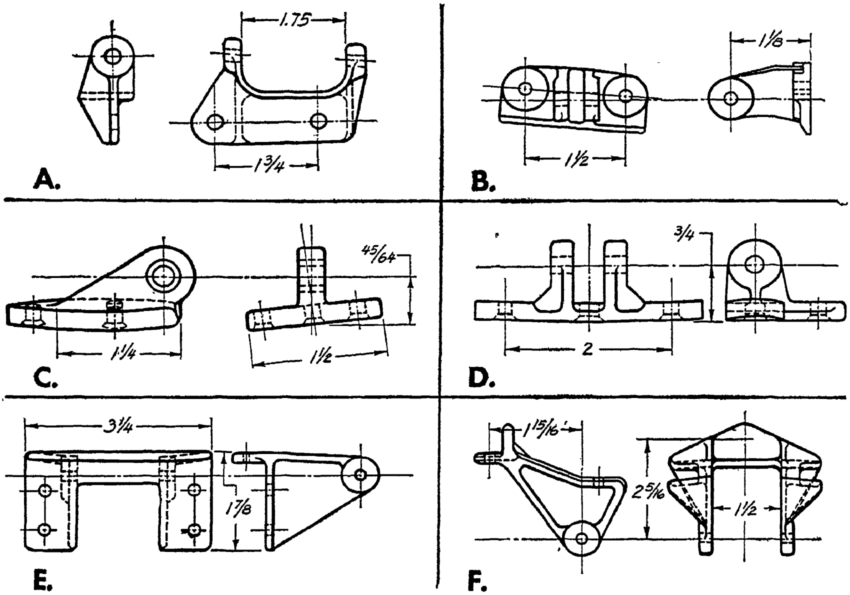


Fig. 2.

Bracket	Unit costs for completed parts	
	Sand-casting	Die-casting
A	$0.56	$0.47
B	0.40	0.33
C	0.45	0.38
D	0.47	0.39
E	0.75	0.62
F	0.90	0.75

Remarks. These brackets are ideally suited to die-casting, and the quantity required is sufficient to reduce the unit die cost to a negligible value.

Kind of Part. Link rod assembly
Quantity. 150
Nature of Change. From SAE X4130 steel forging to SAE X4130 steel sand-casting
Effect on Weight. None

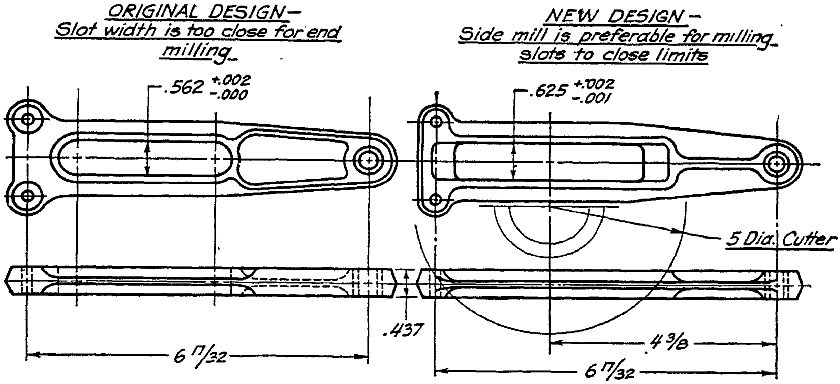


FIG. 3.

Original Design. Forging:

Die	$1.32
Forging	0.52
Labor	0.77
Unit cost	$2.61

New Design. Sand-casting:

Pattern	$0.14
Casting	0.70
Labor	0.80
Unit cost	$1.64

Remarks. The bushing cost is neglected in this comparison for it will be the same for either design. Tooling costs will also be the same. The slot should be machined by side milling as shown at the right-side view because the slot width tolerance is too small for end milling.

Kind of Part. Hinge bracket
Quantity Required. 150
Nature of Change. From 14ST aluminum-alloy forging to 24ST aluminum-alloy riveted assembly
Effect on Weight. 0.025 lb. increase

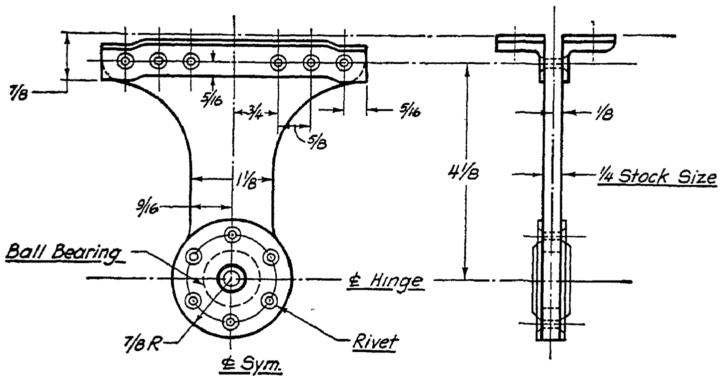


FIG. 4.

Original Design. Forging:

Die	\$2.60
Forging	0.52
Labor	0.50
Unit cost	\$3.62

New Design. Riveted assembly:

Material	\$0.38
Labor	0.43
Extra tools	0.21
Bearing retainers	0.02
Unit cost	\$1.04

Remarks. The high cost of aluminum forgings renders the use of riveted assemblies desirable whenever small quantities are involved.

Kind of Part. Threaded sleeve
Quantity. 150
Nature of Change. From die-casting to machined from rod, using equivalent material
Effect on Weight. None

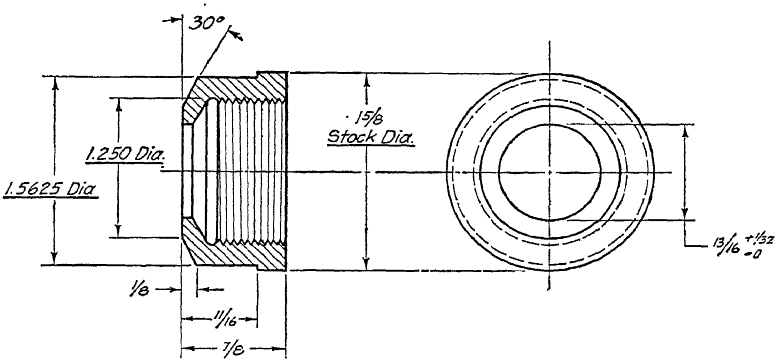


FIG. 5.

Original Design. Die casting:

Die	$0.90
Casting (completely finished)	0.32
Unit cost	$1.22

New Design. Machined from rod:

Material	$0.09
Labor	0.23
Unit cost	$0.32

Remarks. The part is ideal for turret-lathe production from rod. The small quantity raises the die cost to a prohibitive value, and the internal thread must be machined in either case.

Kind of Part. Bearing retainer
Quantity. 80
Nature of Change. From machined from bar stock to sand-casting, using equivalent material
Effect on Weight. None

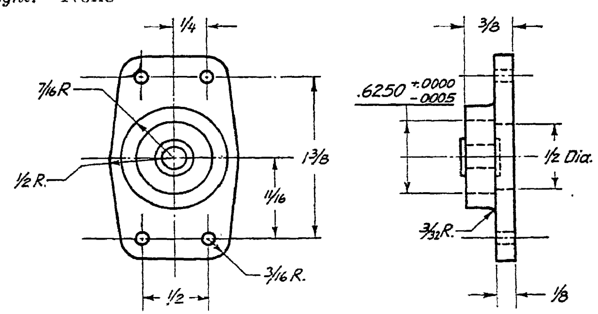


FIG. 6.

Original Design. Bar stock:

Tooling	$0.30
Material	.07
Labor	.36
Unit cost	$0.73

New Design. Sand-casting:

Tooling	$0.39
Material	0.05
Labor	0.21
Unit cost	$0.65

Remarks. Higher cost when machined from bar stock is due to profile milling operation.

Kind of Part. Bushing
Quantity. 150
Nature of Change. From SAE X4130 tubing to SAE X4130 rod
Effect on Weight. None

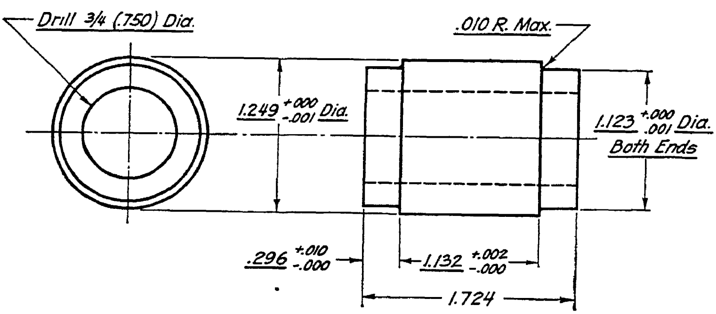


FIG. 7.

Original Design. Tubing, 1⅜ OD by 5⁄16 wall:

Material	$0.28
Labor	0.18
Unit cost	$0.46

New Design. Rod, 1 5⁄16 OD:

Material	$0.11
Labor	0.20
Unit cost	$0.31

Remarks. The tubing cost is more than rod, but machining is the same in each case because of the necessity of drilling the tubing.

Kind of Part. Spanner nut
Quantity. 300
Nature of Change. From SAE 1020 rod to SAE 1020 tubing
Effect on Weight. None

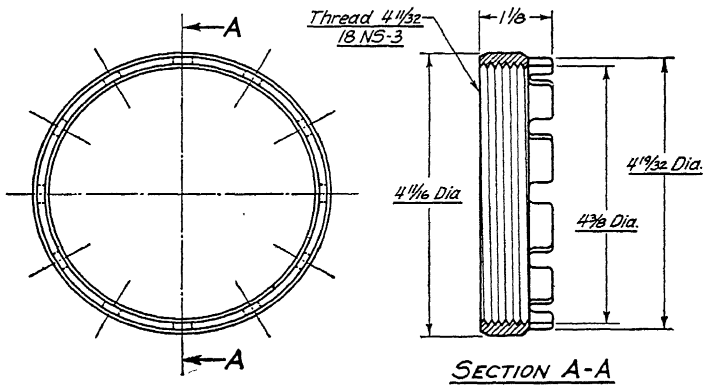


Fig. 8.

Original Design. 4¾ OD hot-rolled rod:

Material	$0.30
Labor	3.30
Unit cost	$3.60

New Design. 4¾ OD by ¼ wall tubing:

Material	$0.21
Labor	2.57
Unit cost	$2.78

Remarks. If this part were made from alloy-steel tubing, the cost would be more than when made from rod, owing to the price differential between carbon and alloy-steel tubing.

Original Design. Casting:

Casting	$0.50
Pattern	0.35
Tooling	0.77
Labor	1.50
Unit cost	$3.12

New Design. Weld assembly:

Material	$0.32
Tooling	1.04
Labor	1.36
Unit cost	$2.72

Kind of Part. Riveted assembly
Quantity. 150
Nature of Change. From square tube stiffener to bulb-angle extrusion stiffener, same material.
Effect on Weight. None

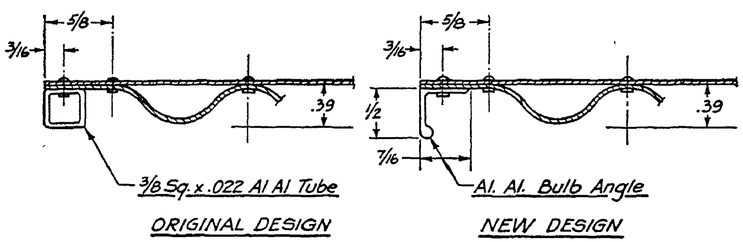


FIG. 12.

Original Design. Square tube:

Material	$0.45
Labor	1.24
Unit cost	$1.69

New Design. Bulb angle:

Material	$0.23
Labor	0.90
Unit cost	$1.13

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